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UNITED NATIONS' CONFERENCE ON FOOD AND AGRICULTURE

By ALONZO E. TAYLOR

EMERITUS DIRECTOR, FOOD RESEARCH INSTITUTE, STANFORD UNIVERSITY

THE Conference, classed under *Foreign Affairs*, was held at Hot Springs, Virginia, under the auspices of the State Department, between May 18 and June 3, 1943. It was presided over by an elder statesman in agriculture, The Hon. Marvin Jones of Texas. The first topics before the Conference were inquiries into natural science—productions and behaviors of agricultures (but not including fisheries), and physiological needs and psychological wants in the patterns of diets that vary from country to country. The technical field was not *terra incognita* to scientists. During the inter-war decades, researches in production, distribution and consumption of foodstuffs were active and widespread, and developed with superior experimental and statistical methods. Deep spadework was done during the depression of the thirties. The League of Nations and the International Labor Office; the International Institute of Agriculture; governmental Departments of Agriculture more or less over the whole white world, but especially in the United States where the yearbooks from 1936 to 1942 were veritable mines of information; the National Resources Board; independent research organizations of widely different kinds; these, with innumerable special researches by widely scattered scientists, had clarified many issues and notably extended the horizon of information. Even for such backward countries as China and India, elaborate studies had been issued by Buck, Mukerjee and Rao. It is fair to add that, since our first National Nutritional Conference was held as late as 1941, publications under the League of Nations during the thirties constituted the broad public introduction. A rough forecast of the recent Conference was made in the January (1943) number of *The Annals* of the American Academy of Political and Social Science by F. L. McDougall of Australia, long an official in the League of Nations. The representatives of the different countries attending the Conference met more as scientific colleagues than as political delegates.

The less direct topics on the Agenda were sociological and economic. They were composed of questions less definite at the moment, perhaps even incidental, but later to be of major importance—problems of stocks and distribution, communications, transportation and refrigeration, exchanges of goods and services, equations of balances of trade.

Finally, not stressed on the Agenda—somewhat like uninvited guests casting shadows over restrained deliberations—were long-term, secondary problems of interrelations of nutritional reform to clothing, housing, sanitation, education, rates of birth and death, rates of growth

and changing densities of population, and eventual migration from higher to lower densities during coming generations. All in all, the subject matters on the Conference program represented inquiries primarily into natural science, and secondarily into social research.

The Conference met to consider post-war goals of world-wide and ultimate "freedom from want" in relation to food and agriculture. The word "want" was used more in the sense of material well-being, less in the sense of "want" used in economics. "Freedom from want" presupposed freedom from hunger; "freedom from fear" presupposed "freedom from want." Thereafter, freedom from want and fear presupposed balanced and world-wide expansion of economic activities, which to achieve would need *long-term post-war reforms*—collectivization of world agriculture and socialization of world trade in foodstuffs.

President Roosevelt several years ago broadcast the national reproach that a third of our population was under-fed, under-clothed, and under-housed. Then Henry A. Wallace revived the doctrine of the "Revolution of the Common Man." Anglo-American solidarity in August, 1941, created the Atlantic Charter. At the beginning of the European struggle arose the slogan (somewhat modified from the previous war): "Food will win the war and make the peace." Since the United States entered the war, Europeans (belligerent and neutrals) have taken this slogan literally; the United States has become the geographical name for "manna-from-heaven." Under these circumstances, it became apparent that, whether the war were to last three or five years after 1941, the United States needed vigorously to organize resources in agriculture and to plan the distribution of agricultural products at home and abroad. Under the emergency predicted by the slogan, these objectives were publicly focused in the United Nations' Conference on Food and Agriculture.

Scope of Agenda

The Conference derived directly in spirit, and indirectly in convocation, from the Atlantic Charter. Point 5 in the Charter stated that the President of the United States and the Prime Minister, Mr. Churchill, representing His Majesty's Government in the United Kingdom, "desire to bring about the fullest collaboration between all nations in the economic field, with the object of securing for all improved labor standards, economic advancement and social security," with "access on equal terms" for all countries "to the trade and to the raw materials of the world which one needed for their economic prosperity," as set forth in Point 4. Early in the war the British Government erected an outpost; as early as August, 1940, Prime Minister Churchill had accepted for the victors the obligation to build up reserves over the world, so that all countries should recognize that victory of the Allied Nations would bring, for all, immediate food, freedom and peace. A conference was held in London in September, 1941, at which practical plans were started to provide liberated peoples "with articles of prime necessity" directly after the war, and a commission was set up under Sir Frederick Leith-Ross.

It is important to envisage the collateral economic implications. In the convocation of the Conference, the State Department included within the intent of "improved labor standards, economic advancement and social security," with access to trade and raw materials, the special improvement of nutrition for man and of the agriculture necessary to maintain it. Under these circumstances, the inclusion of food and agriculture under Points 4 and 5 of the Charter represented an important, dynamic interpretation by the Department of State.

The countries represented at the Conference numbered forty-four, including several refugee governments (combined population 1.6 billion): *Europe*—United

Kingdom, Norway, Netherlands, Belgium, Greece, Iceland, Luxembourg, Free France, Czecho-Slovakia, Poland, Yugoslavia, Russia; *Africa*—Egypt, Liberia, Union of South Africa, Ethiopia; *Asia*—China, Iraq, Philippines, India, Iran; *Western Hemisphere*—Canada, United States, Mexico, Cuba, Dominican Republic, Haiti, Venezuela, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Ecquador, Peru, Bolivia, Brazil, Paraguay, Uruguay, Chile; *Oceania*—Australia, New Zealand. In the absent minority of the world were twenty enemy and neutral countries as follows (combined population 0.5 billion): *Europe*—Finland, Sweden, Denmark, Eire, German Reich, Switzerland, Portugal, Spain, Italy, Hungary, Roumania, Albania, Bulgaria; *Asia*—Turkey, Arabia, Afghanistan, Thailand, Tibet, Japan; *Western Hemisphere*—Argentina. Since the Agenda of the Conference dealt with long-term post-war reforms, all countries of the world are eventually to be brought under the aegis of the reforms and innovations inaugurated by the United Nations.

The topics on the Agenda covered the broad field of *long-term post-war reforms* in relation to national patterns of diet and to scope and efficiency of national agricultures. No discussion was proposed for the immediate factual role of food in winning the war or making the peace. Throughout the transactions of the Conference there were comments on monetary stabilization, lower tariffs, elimination of arbitrary and unilateral obstacles to trade, freedom of the sea and air, stabilized foreign exchanges—in general, freedom of the flow of goods and services as broadly stated in the Atlantic Charter.

Between the termination of food relief and the reestablishment of peace economy, a period of transition will emerge which may occupy several years. There must be two stages in the long-term post-war reform of agriculture. One is preliminary repair of devastation of war, which may be extreme after a country has been "scorched"; there will be much of such reconstruction in Poland and Greece, less in Holland and Norway. The second stage represents the planned shift from calories to protective food-stuffs, which will vary from country to country in accordance with the respective patterns of pre-war diet.

Demand and Supply, Surplus and Shortage

The deliberations of such a Conference rest finally on statistical data. Agricultural and commercial reports in 1938 were the best in history, representing a cumulation of improvements in methods and interpretation during the inter-war period. The war has thrown statistical estimates into confusion, least for those pertaining to fruits, vegetables and grains and most for animal products. Rationing, somewhat paradoxically, has confused the situation; but in outside countries not under ration, disturbances in distribution provoke baffling uncertainties. For many of the other forty-three members of the Conference, the League of Nations and the International Institute of Agriculture knew more about their food productions in 1938 than did their local officials.

In order to enter upon reforms of diet and agriculture, each country will need to know what it obtains from harvest and import, from season to season; and what it ingests from season to season. Production comes first: we follow crops into use; we do not, as a rule, trace use back to crops. When we study the protective foodstuffs we give special attention to consumption; but dealing with bulk and calories, we start with crops and animal husbandry. Our knowledge of protective foodstuffs grew partly out of the study of poverty-diets occurring during the depression of the thirties. Chemical research on vitamins and their syntheses,

biological experimentation on the effects of vitamin deficiencies and clinical observations on naturally-occuring deficiencies have proceeded hand in hand in some countries, especially in Britain and the United States. Unfortunately for the world-wide dissemination of data on standards of diets, few countries have Orrs, Wilders and Stiebelings.

Farmers in this country follow one or more of three supporting influences when "goals" of increased production are set up in order to create exportable surplus: (a) federal and state Departments of Agriculture, with Extension Service and County Agents, and supported by various loans and subsidies from the federal government; (b) institutional farm organizations, such as the National Grange, the Farmers' Union, and the Farm Bureau Federation; (c) cooperatives, which in some regions are very influential in directing farm practice. The difficulty in the past was that farmers were expected to "venture" into increased production, with consequent inflation but later risk of deflation. Indeed, many of the so-called "surplus problems"—national and international—in the disposition of farm products (called "commodities in chronic surplus" in the Agenda), had their origins in the stimulation of production for the purpose of export or self-sufficiency. In substituting a doctrine of plenty for that of restriction, reforms in foreign agricultures must not become the bases for autarchy.

Records of imports and exports are usually more accurate than those of crops; it is the flow that is difficult to follow. Each of the *forty-four* countries represented at the Conference (and later the absent enemy and neutral countries) will need to prepare post-war programs of agriculture and goals of production of foodstuffs, and to tabulate these on their widely different pre-war patterns of national diet. Thereafter each country will need to revise the traditional pattern of its diet—which in most countries had records only of protein, fat, carbohydrate and total calories—to include essential amino-acids and fatty acids, iron and calcium (perhaps other minerals), and thiamine, riboflavin, niacin, ascorbic acid, vitamins A and D, and perhaps others. Crop reports will need to be revised and reviewed to take account of protective foodstuffs as well as of traditional staples.

These protective components will need to be scheduled in the various native products and in imports from usual sources. Unfortunately, adequate analytical, experimental and clinical information will not be available to most of these countries; consequently farmers and households will be confused, and progress delayed. Also, few countries will be politically in position to face the legislative question of subsidies to improve diet of low-income classes. Practical applications will take time and will undergo trial and error; old superstitions and taboos, even religious ceremonials, will need to be corrected. The backward countries will offer deep-seated objections; but even among advanced peoples there will be resistance to the transformation of traditional patterns of diet into modern nutritional patterns. That the agricultural "goals" of 1943 need to be heavily revised and enlarged into "master plans" for 1944 illustrates trial and error procedures under even the most expert farm administrators. How well the forty-two allied nations have learned from Great Britain and the United States during the present Conference will be revealed only in the decade after the resumption of peace, on paper at least.

We must separate occasional shortage from continuous scarcity, and crop failure from income failure. The famine of crop failure is usually one of scarcity of caloric foodstuffs; the hidden hunger is usually due to scarcity of protective foodstuffs. "Food-piles," "carry-overs," "buffer stocks," "ever-normal gran-

aries"—the variously-named warehouse-stocks for needs in occasional exigencies—do not cover the ultimate requirements of low-income classes. India has a bad monsoon failure once in ten years but has severe income failure every year. Since causes, locations and extents of different kinds of shortages are widely different, no single remedy is appropriate. Long-term stocks are possible only for grains, sugar, coffee, lard and mess pork in cold storage, dehydrated vegetables properly packed, and possibly dried fruits and legumes. The public finds it disconcerting to see, side by side, plans for "ever-normal granaries" and projects for control and allocation of "surpluses" in staples like coffee, wheat and sugar.

When, therefore, the Conference placed upon member-countries the injunction to prepare schedules of crops in the order of importance of nutritional components and schedules of diets by regions and income classes—all of which will be needed if the proposed reforms are to be seriously undertaken—the Conference exacted tasks of large and continuing difficulty. What is needed for guidance in each country is formulation of facts and projects in the national nutrition, such as has been prepared for this country under the editorship of John D. Black and published under the title "Nutrition and Food Supply" in *The Annals* of the American Academy of Political and Social Science for January, 1943, and supplemented by the various issues of the United States Department of Agriculture. It is to be hoped that Conference procedures will lead to statistical clarification of factual occurrence, extent and localization of surpluses and deficiencies in particular food supplies, in all significant countries. These are not to be adjudged by reports on crops, imports and exports; in some instances not even by data of total supply, disappearance and ingestion. A number of countries are net-exporters of caloric foodstuffs; there are few significant net-exporters of protective foodstuffs. In any year, the food supply of the world may be unknown to the extent of plus or minus five per cent, perhaps in some years ten per cent.

Qualitatively evaluated, we tend to exaggerate dietary deficiencies and underestimate dietary excesses. It is accepted in this country—with the highest standard of living ever achieved by a population as large as ours—that before the war a third of the inhabitants were poorly nourished (in the mid-thirties) in respect to protective foodstuffs, to an extent permitting objective (if indirect) diagnosis of mild degrees of malnutrition. If this held true in the United States, it must have been equally true in other surplus countries, such as Australia; and worse in Argentina, where field surveys of the pampas revealed surprising neglect in the use of protective foodstuffs. Certainly, applied to larger and older countries in the world, if Americans have (mild) malnutrition in a third of the population, this will be found to affect half of the population in many countries, and two-thirds or even three-fourths in certain large countries like China and Japan—as confirmed by surveys. In India, the usual deficit in food supply is ten per cent. into the "famine zone." Without question, a careful, dynamic study of the statistics of the pre-war food supplies of the world would indicate surprising extents of shortages in protective foodstuffs; often more than moderate, with here and there relative surplus of caloric foodstuffs. In our country possibly a third of the population over fifty years of age is over-nourished and over-weight due to excessive ingestion of calories (including alcohol) which leads to cardiovascular disease, long-recognized in life-insurance statistics.

In all countries, some neglect of protective foodstuffs was due to ignorance; in most countries it was due still more to lack of purchasing power in low-income

classes. Sometimes noted are extraordinary perversions in agriculture, most glaring in India; but it is possible that in many advanced countries, surveys of agriculture would suggest that the diet of domesticated animals has been superior to that of the human population—because animal husbandry was under the influence of scientific doctrine while the pattern of the human diet was surprisingly under the influence of superstition, prejudice, and ignorance.

With due regard for occasional or even conspicuous instances of excessive ingestion of foodstuffs in advanced countries—as revealed in overweight, obesity, cardiac disease, and diabetes—these may safely be left to the medical profession. But deficiency diseases due to shortage of protective components of the diet cannot be left to the medical profession, since prevention is not to be secured except through education on scientific nutrition brought to the public schools, to parent-teacher associations, households and public eating places. Presumably, the urgency of war will give to post-war reform in dietary patterns the high rank in public health needed to assure well-being in all income groups.

Implications

Directly explicit and indirectly implicit in proposed global planning are the following factors:

(1) The contrast of the low level of gross national production in the depth of the present depression with the present higher level provokes the social reflection that it ought to be a first-order function of a state to maintain in peacetime the high gross production attained in wartime. Surely it is to be regarded as a reflection on society that it can rise to high production for purpose of slaughter but cannot continue high production for purpose of conservation—that it perfects the standard and plane of killing but is unable to perfect the standard and plane of living.

(2) In the platform of adequate nutrition for all countries, it seems to be accepted that accustomed patterns of different diets can be so modified as to enable all peoples to be fed adequately on the gross supply of foodstuffs, as this may be modified and expanded by plant agriculture, animal husbandry, forestry and fishing. But when it is realized that two-thirds of the inhabitants of the world live in areas where population presses hard on food supply, it becomes obvious that more or less coercion (of an educational nature) may need to be applied regionally to rejection of dietary dicta of religions, superstitions and taboos. When we deal with national patterns of diets, we come to appreciate distinctions between bodily needs for nutrients and consumers' desires for foodstuffs. The backward peoples must be taught to be fed scientifically, just as domesticated animals are handled by farm management.

(3) It is assumed that the science and art of agriculture have been so developed as to be applicable horizontally and vertically, acceptable to all regions, latitudes and longitudes, in all soils and climates, and to all peoples—highly advanced, less advanced, decadent, backward or primitive. We lay out "goals" and "master plans" for agriculture which, in the absence of any climatic calamities in peacetime, might be expected (costs aside) to double gross production of feedstuffs, caloric foodstuffs, protective foodstuffs and domesticated animals on per capita bases within ten years. Such rural objectives ought to be relatively feasible in advanced countries with low densities of populations, but they become more and more difficult in regions with high densities of populations.

(4) More widely and insistently, it is being urged that advanced races ought to accept migration of other races from

areas of high to areas of low density of population, particularly when unutilized agricultural resources are readily available in countries of low density of population. Perhaps not the "open door" of migration, but at least notably liberalized quotas of immigration are being advocated. In part, the problem is one of divergencies in industrialization and in definition of living standards; but if these could be resolved on the basis of accepted per capita requirements, the racial problems of interbreeding would still remain.

(5) Like reservations apply to clothing and housing. These are closely related to sanitation and to nutrition, with many points of contact; difficulties lie in religions, superstitions and taboos, which radiate through the living of two-thirds of the inhabitants of the world. And reform can not associate with illiteracy.

(6) It is assumed that "free trade" will replace "restriction"; this is better stated by saying that freer trade is to replace less-free trade. It is expected that each country will attempt first to elevate its attained standard of living.

(7) It seems to be assumed that technical reforms in agriculture, freer trade and efficient distribution of foodstuffs from country to country can be accomplished within the present scope and application of scientific sanitation. Unfortunately, such assumption is not well-founded. Religion, superstition, taboo and ignorance directly and indirectly influence practices of agriculture and distribution and uses of foodstuffs in Africa and Asia (disregarding small *foci* elsewhere), representing nearly two-thirds of the entire world population. A study of the problems of communicable diseases of animals in Asia and Africa indicates the enormity of the task of protecting the Western Hemisphere and Europe from the insanitation of Asia and Africa. Involved also are large questions of sanitation in relation to the distribution of communicable diseases of human beings—the control of typhus, yellow fever, malaria and bubonic plague, to mention the most prominent infections. Lesser questions concern the supply of pure water, sewage disposal, reduced mortality of infants, and elimination of intestinal parasites, in all of which Europe and the Western Hemisphere are far ahead of Africa and Asia, both in theory and practice.

(8) Planned economy, including important social relations outside of commercial enterprises, might lead to a three to four billion increase in the population of the world in the course of one or two generations. The rapidity of such increase of population would depend upon the success of the sum total of efforts to make life "secure," to raise the statistical standard and plane of living, to lower the proportion of the population submerged in destitution, and to achieve the so-called "freedom from want" and "freedom from fear." Let it be emphasized that in such eventual increase of world population the rate of growth would be expected to rise most in Asia and Africa, possibly in Russia and Brazil, but not notably in western Europe, in the Western Hemisphere or in Australasia. The net result would be a declining proportion of Europeans and their descendants and an increasing proportion of African and Asiatic races in the world, as indirect but inevitable result of what has been called the "Revolution of the Common Man." Thus we revert to Malthus: pressure of the population on food supply, instead of pressure of food supply on the population as proposed by the projected reforms.

Prospect

Each of these reforms may seem *qualitatively* sound on technical and statistical grounds. But on making *quantitative* appraisal of methods to be used, and of the *time element*, it is difficult to avoid the realistic conclusion that any moderate

attainment expected within a few years may require a decade or more; that the larger realization expected in a decade may require a generation or two. The progress will be one of slow evolution rather than rapid revolution. If we measure in this country the ignorance prevalent in young, as well as old, on matters of food supply, nutrition, disease and sanitation; if we recognize how slow public progress here has been since the close of the first World War, and then multiply this reservation by from two to twenty in estimating the prospects of reform in various foreign countries, we obtain a more realistic forecast of the future than is found in political programs.

Two broad proposals were adopted at the Conference: that each participating country first make a national survey of food supply, nutrition, and agriculture, and then decide to what extent deficiencies in national nutrition are due to inadequacies of agriculture or to low national income and inequality in distribution. Here science will run counter to tradition and custom in most countries.

From this point on, in each country farm activities and non-farm activities are to be reformed. (a) Farm activity is to be reformed intensively and extensively by local advances in the uses of the art and science of modern agriculture. In some countries, it may be felt proper to propose parcellation of land; a changed system of taxation of land; loans to agriculturists; public assumption of stocks, carry-overs and marketing; and various enactments or subsidies to assure the desired proportion of caloric and protective foodstuffs in the national diet. Some countries will require allocation of open sea fishing; this will be defined as related to the internal food supply and will rest objectively on international adjustments. Some of these steps have been tried only in several advanced countries. One special point in the reform is technological, perhaps financial, aid of backward countries by advanced countries.

(b) In each of the countries included in the projected reform will be non-farm reform as well as farm reform. Extension of refrigeration is a much-needed improvement in transportation. Transportation and communications will need to be adapted to projected closer international relations; indeed, it is suggested that appropriate control of transportation and communication by the state for internal purposes may be found necessary to effectuate international control of transportation and communication for global purposes. In general, it becomes clear that an outstanding feature sought in the proposed reform is extension of public enterprise, partly in substitution of private enterprise but also as an extension into fields not yet developed. But farm relief means commercial profit, since farming is to remain private enterprise.

(c) Included for each country, for both the rural and urban population, are the aims of high production, full employment, large national income with equitable distribution for consumption, and savings by regions and classes. For many countries, this will involve internal monetary reform. That such monetary reforms within states may involve revaluation of money, allocation of bank credit, and redistribution of wealth, even at the risk of expropriation of capital, is accepted by reformers as possibly inevitable, following the history of monetary aberrations during the past thirty years.

(d) For each country is implied a planned economy between farm and non-farm, also within farms and, of course, within industries. The extreme proponents of this reform do not shirk from vertical and horizontal projections, because reform is designed within countries to bring about the end of traditional laissez faire; thus the best prospect of success in such reform is held to be clear realization and full enunciation of the direct applications and the indirect implications for private enterprise.

Within the participating countries, the initial reforms obviously go far beyond food supply and agriculture, as fully recognized in the transactions of the Conference. Orders of precedence, methods of application, volume and velocity of planned changes are, of course, all subject to variations from country to country, depending upon material circumstances and psychological characteristics. Certainly reform in China would be different from reform in India; reform in Asia and Africa would be different from reform in Europe; and reform in Europe would be different from reform in the Western Hemisphere. What is sought by proponents is clarity of objectives (ends), and continuous pressure (means) toward practical beginnings in all countries. Each participating country will need to define food production, commercial surplus or deficit, demonstrable dietary deficiencies and the supplementations needed to make local patterns of diet adequate. So much, briefly, for the internal national projects, the speed of which will tend to be incautiously precipitated by sentiment in some countries and retarded by fear in others.

Once these forty-four countries have prepared their surveys of diet patterns and nutritional deficiencies, and their agricultural potentialities and deficiencies, these separate national internal reforms will be sought to be welded into an international body of reform. Here enter many difficulties, fully recognized by the proponents of the movement. These difficulties lie largely in international relationships.

(1) With respect to the exchange of goods and services as such, it is assumed that each country will seek high production, full employment, large national income with savings offset by capital investment adapted to the country's policy. This will ensure enlargement in absolute volume and possibly also in the relative proportion of foreign goods and services—expansion in foreign trade, in short. Such interchange is, indeed, stipulated as necessary to the predicated high production, full employment and large national income within countries. Both positive and negative influences will need to be invoked. The negative corrections imply reduction in impediments to the flow of goods in foreign commerce, of which both the difficulty and the desirability are fully recognized in the diplomatic circles of all liberal countries. The positive method of encouragement of the flow of goods and services in foreign trade lies partly in internal adaptations and in high production, but mostly in adjustments to be sought under the captions which follow.

(2) With respect to the facilitation of the media of exchange, it is accepted in theory and practice that expanded foreign commerce is not to be sought on the basis of bilateral trade or unilateral valuation of money or barter, but instead on the basis of multilateral commerce, as illustrated recently in a book, *The Network of World Trade*, issued by the League of Nations. The proponents of reform are conspicuously united in advocacy of the expansion of foreign commerce on the multilateral pattern, with every possible removal of impediments to foreign trade. Before the United Nations at present are two proposals—one drafted by Lord Keynes for the British Exchequer, the other by Harry D. White for the United States Treasury—looking toward the restoration of order and computability in the field of foreign exchanges, the elaboration and stablilization of the media for payment of goods and services in multilateral trade, and for seasonal equation of trade balances between countries.

(3) With respect to foreign investments, two things seem to be anticipated. With due recognition of the valuable services of foreign investment in the development of the world since the begin-

ning of the industrial revolution, such foreign investment can not be expected to be revived after the next peace in the form that was acceptable and effective prior to 1914. The material interests of the borrowing countries must be projected and conserved to an extent not invoked prior to 1914; both lenders and borrowers need to envisage an improved type of foreign investment. The subject of foreign investment is, of course, connected with developments in transportation and communication, freedom of restraint in the flow of goods in multilateral trade, and especially with the determination of a world-wide and effective stabilization of currencies and exchanges. When we consider together the difficulties and dimensions related to the free movement of goods in international commerce and to the freedom of communications and efficiency in the operations of the media of exchange, and contrast these with the reform in food and agriculture as envisaged in the transactions and resolutions of the recent Conference, we come to foresee what the word "global" means; and come also to appreciate—fully envisaged by the supporters of the projected reform—the extent to which advances in the several interrelated fields must be encouraged and elaborated if the horizontal extent and the vertical depth of the global reform in food and agriculture are to be secured in anything like the time expected by the recipients of improvements in the less advanced and backward countries of the world.

(4) The tremendous sinkings in ocean tonnage, the geographically irregular restoration by new construction and consequent deterioration of transportation by canal and rail, the veritable revolution in transportation by air, together with possible expansion of transportation by highway more or less over the world—these together create problems both large and urgent, on which directly rest the success of reform in food supply and agriculture. What is sought in general terms is freedom—freedom of the seas, of the air, of ports and communications—all these in the international sense, with appropriate reflections of freedoms within countries. In view of the planned increase in global production and the related expansion in international commerce, the equitable and efficient correlation of newer and older modes of transit will be one of the outstanding problems in the transition to peacetime economy in many countries.

In order to forecast volumetrically, so to speak, the dimensions involved in these problems, we need merely to point out that food and drink use one-fourth to one-third of the national income in the most advanced countries, three-fourths of the national income in the most backward countries having high concentrations of population, with other countries occupying stations all the way between. Highly important for the success of the reform in food supply and agriculture are coincidal reforms in clothing, shelter, sanitation services, and education; indeed, it is not to be expected that satisfactory reforms in food and agriculture can be attained without such simultaneous intensive and extensive reforms. But in the early stages of correlated reforms, the large proportion of global income devoted to nutrition is such as to give food supply priority in global reform.

(5) Finally, we arrive at what later will become the most difficult phase of the projected reform—namely, the relations between populations in different continents. Reactions will soon become vividly manifest. When the tabulated reports on diets and agricultures of the forty-four countries are contrasted from standpoints of actual nutritional patterns, relations of population to area of cultivatable land (dynamic density of population), birth rates, death rates and expectations of life, and prospective rate of growth or decline of national popula-

tions, it will then become apparent that reform will be relatively easy and quick in a country in which high efficiency of agriculture tends to produce a pressure of food supply on population which will make feasible the attainment of optimal diet. But the reform will be extremely difficult and deferred in a country in which demonstrable efficiency in agriculture still fails to produce such a food supply for the population involved as will prove nutritionally adequate, unless supplemented heavily by imports. One has only to compare India and the United States. The total area of India is less than that of the farms in this country; since the population of India is now estimated at four hundred million and that of the United States at one hundred and thirty-five million, it becomes arithmetically obvious that each inhabitant in the United States possesses, so to speak, in land within farms, three times as much area as is possessed by each inhabitant in India in all the land of that country. If we were to draw the contrast between land in farms in this country and land under agricultural operation in India, the per capita divergence would become still more glaring. We have in this country no such major division within the population as is to be seen in India between Hindu and Moslem; no "untouchable caste" and "sacred cow" of which Americans have not even a hypothetical picture. The agriculture of this country is scientific; that of India is chained with superstition and taboo, shackled with ignorance and disease. Our country potentially requires no imports to supply adequate diet; adequate diet in India could only be secured through colossal imports, for decades at least. Adequate diet in India would be accompanied by an increase in the rate of population growth, which no one expects in the United States.

From this contrast emerges total difference in prospect for the projected reform in the United States and in India. With these as extreme illustrations, all of the other countries would occupy intermediary positions, more or less difficult according to their differences in population, areas and resources.

The summary of views and recommendations of the Conference, issued before adjournment, apply to the countries which have accepted, perhaps with misgiving but with more or less enthusiasm and emotion, the projected reform in food and agriculture. In the expectation of Allied victory, however, this leaves out of consideration twenty countries, depending upon the outcome of the treaty of peace. Also, it leaves unclear the future status of colonies and dependencies, in the broad sense. Included thereunder are: (a) all of Africa lying between the Union of South Africa and the countries from the Levant to the Atlantic that border on the Mediterranean Sea; (b) also all of Asia outside of Japan, China and Asiatic Russia; (c) all of the islands south and east of Asia and north of Australia. If the status *quo ante bellum* of colonies and dependencies remains, one type of difficult problem will result; if all colonies and dependencies are to be freed, another type of intricate problem will emerge. It is a principle of the proponents that their reform is to apply to all regions and countries—advanced, less advanced and backward, all must be brought in. This not only involves extraordinarily complex and unsuitable patterns, both of diet and agriculture, in the regions to be retained or freed; but also the solution with respect to the future status of these large areas will complicate greatly the reforms in transportation and communications, currency and exchange and foreign investment. If these areas are to retain status *quo ante bellum,* reform of agriculture and of pattern of diet in their retained areas remains the responsibility of the

countries controlling them. But if these colonies and dependencies are to be freed and established as autonomous units, is their participation in this reform to rest upon their inexperience in government, or are they to become for a generation the charity charges of the world?

The British Commonwealth of Nations and the United States combine ideology and driving force in this projected reform; we are to be the major donors, the others are to be mostly recipients. If colonies and dependencies are to be reformed, in patterns of diet and agriculture, outside the frameworks of the British Commonwealth of Nations, Holland, Belgium and France, such enforced emancipation of large areas would be more violent than the separation of the Western Hemisphere from Europe in recent centuries.

It can not be suggested that these questions are far-fetched. These questions will arise just as soon as the Interim Commission spreads out the reports from the forty-four countries on national pattern of diet and national status of agriculture; they will become even more obvious when the unrepresented neutral and ex-enemy countries are eventually included in the subsequent survey. The peoples of Asia and Africa—of their own volition but aided by encouragement of Anglo-American ideologists—expect, ask for, and will later demand that the promises held out in the Anglo-American recognition of the "Revolution of the Common Man" shall be incorporated into their standard of living, and with energetic foreign assistance. The entire tone of the Conference seemed favorable to collective planning, for occupations and for regions. The type and extent of the reconstruction of agriculture in the first decade of peace will reveal whether the oldest and most individualistic of occupations has become amenable to planned economy.

In seeking post-war reform in the world, we need to recognize that the evils it seeks to eradicate were not the product of this war or of the last war; nor were they the causes of this war or the last war. However, it is hoped that within the forty-four countries we may find that solidarity for reform which they did not possess during the inter-war period or prior to the first World War. And it is hoped, in some almost magical way, to induce the defeated peoples, under-privileged neutral countries and backward countries all over the world, to join us in a reform for which they do not have the preparation we possess. But should such outside countries perversely decline to go with us, are we prepared—having proclaimed that "the world can not live half slave and half free," that "peace is indivisible," that success in reform for the whole world may be nullified by refusal of significant countries to participate—to impose reform by force? Finally, what is to be the policy of the United Nations if less advanced countries backslide on their agreements to cooperate in reforms being carried out for them as well as for the leading countries?

Proposals accepted by the Conference, in principle and theory, do not bind the members and do not become accepted projects, but pass as recommendations first to the Interim Commission, and then—through them (perhaps directly)—to the participating countries, later to emerge in some form of legislative enactment or executive directive in each of the countries concerned. It is presumed that such enactments and directives will enable a central commission on operation and management to coordinate legislation in participating countries for the purpose of setting up accepted policies of storage, commercial allocation, price acceptance and donation. It is obvious that if such concurrent legislation is made elaborate, it will include elements of cooperative marketing, consumers' cooperations, stockpiles, transportation control, and facilitation of foreign exchange. Experi-

ence suggests that tactics of follow-up will require more attention than original enactment and compliance.

Acceptance by countries participating in the Conference is expected to be followed promptly by legislative enactments and executive directives appropriate in each country. Illustrations of such reforms of the diet are: enrichment of flour and bread; minimal standards for vitamins in processed vegetables, fruits and dairy products; prescription or proscription in processing; and standardization in the preparations of vitamins. Indeed, such regimentation may go as far as to prescribe feeding of dairy animals for purpose of natural enrichment of milk and butter. Stress is to be laid on the coordination of production (plus imports) with consumption, using the yardstick of optimal nutrition. Some of these provisions will sound as distant to many of the countries as the proposals of the National Resources Planning Board now sound to most Americans.

The Conference took action, on appointment of an interim commission, to draw up plans for permanent organization from which could follow a second international conference, with a more specific agenda, after a suitable lapse of time following the reestablishment of peace. Whether ex-enemy and neutral countries will then join with the United Nations, and accept their leadership in reform of food and agriculture, can not now be predicted.

A week after the adjournment of the United Nations' Conference on Food and Agriculture, it was unofficially disclosed that a United Nations Conference on Relief and Rehabilitation is in the course of preparation. The questions of responsibilities for losses, costs and outlays will loom larger in discussions of relief and rehabilitation than in the program for the reform of food and agriculture. Neither this reform nor relief and rehabilitation can be settled until political peace and geographical adjustments are attained.

Subsequent to the adjournment of the Conference, the State Department issued formal "*Recommendations*" of Sections and a "*Final Act.*" These contained declarations of principles and policies with detailed submissions of projects and proposed obligations. When these documents shall have been delivered to the home governments of forty-three countries and shall have been translated into forty-two foreign languages, the most extensive international collaboration in the history of the world will have been verbally launched.

SOME QUAINT CONCEPTIONS OF NORTH AFRICAN NATURAL HISTORY

By ARTHUR LOVERIDGE

CURATOR OF HERPETOLOGY, MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD UNIVERSITY

SOME time ago my attention was called to an Algerian dispatch regarding a lizard. Apart from minor exaggerations, such as increasing the creature's length by fifty per cent., the reporter described an African chameleon with sufficient accuracy as to leave no doubt regarding its identification. His comments called to mind the surprisingly good descriptions of this creature contained in an old book whose bicentenary passed unnoticed last year.

This book, *An Essay towards a Natural History of Serpents,* was printed in the year 1742 for the author, the Reverend Charles Owen of Warrington, Lancashire, by John Gray, at the Cross-Keys in the Poultry, near Cheapside. With commendable industry the erudite Owen has brought together everything he could find regarding serpents and, in addition, a surprising amount of matter that has nothing whatsoever to do with them. I have nothing but admiration for Mr. Owen, who has so carefully documented each statement and whose proof reading is almost beyond reproach. In the course of a search for his remarks upon chameleons, however, I came upon so many quaint references to fighting in Libya in bygone times that a few quotations might be entertaining. In such quotations, except for the old fashioned double *s*, the original spelling is preserved.

The introductory remarks suggest at least one use for a snake's tail which has escaped the perspicacity of our modern herpetologists. Owen writes:

Serpents are provided with Tails of different Length and Size; these also are necessary to adjust their Motion, and guard them against Stimulation of Flies. In winged Serpents, the Tail serves as a Rudder to govern them in flying through the Air; and in the marine Serpents, they serve as Oars.

With the last remark no fault can be found, but the affectionate intentions attributed to a snake's flickering tongue appears to be decidedly imaginative:

Mention is made by Historians of harmless Serpents, and of Persons who have tamed Serpents, and whose Hair has been kissed by a tame Dragon, and which, with its Tongue, gently lick'd its Master's Face.

We read of other green Serpents in the Indies, that are indulged with little Cottages made of Straw, where they spend their solitary Hours, till the time of eating invites them out, then they repair to the House, where they fawn upon their Masters, and eat what is set before them, and then retire to the Huts of Indulgence.

We have often been told that the present is a "total war," and yet our Government appears to be taking no steps to mobilize our snakes. What a surprise a few thousand rattlesnakes would cause in enemy trenches if dropped there at night by parachute! For, formerly:

In Times of War, Serpents have been prest into the Service. Thus Heliogabalus (Emperor of Rome, . . .) gathered together several Serpents, contrived a Method to turn them loose, before day, among his Enemies, which soon put them into a terrible Hurry, and a Motion, that was a Trial for their Lives; the Sight of the crooked Serpents being far more dreadful, than the Whizzing of a straight Arrow.

Hannibal having procured a great Number of Serpents, put them into earthen Vessels; and by another Device, and in midst of the Engagement, convey'd them into Antiochus's Fleet, which proved more dreadful than Fire-balls, and feather'd Weapons, that flew amongst them. At first it seemed ridiculous to the Romans, that they should arm themselves, and fight with earthen Pots; but when they were broken, an Army of Snakes rush'd out, which so terrified the Marines, that they immediately yielded the Victory to Prusias, the Carthaginian Hero's Friend.

But, coming to Libya, it is reassuring to learn that:

The Water which amphibious Serpents frequent, receives no venemous Tincture from them. When Marcus Cato commanded in Africa (the Element of poisonous Animals) . . . marching the Remains of Pompey's Army through the Lybian Deserts, observes, how the Army being almost choak'd with Thirst, and coming to a Brook full of Serpents, durst not drink for fear of being poisoned, till convinced by their Superiors, that their being in the Water, did by no means infect it: Upon which they refreshed themselves with Water from the Serpentine River.

Further troubles beset the Roman Army in Libya, however, for we read that:

The Dipsas or Dipsacus is a little venemous Reptile of the Aspick-kind, less than a Viper, but kills sooner; and is most remarkable in this, that when it bites, the Poison brings an unquenchable Thirst on the Person affected, who finding no Relief, runs to the Water, and drinks till he burst asunder. The Poetick Historian observes how Aulus, an Ensign-bearer in the Roman Army in Africa, was slain by this Serpent; at first he felt little or no Pain from the Bite, but as soon as it began to operate, he was immediately scorch'd to death. . . . The more hot the Climate, the more terrible the Wound, as it is in that hot Country, where they have no Springs, but a few salt Wells, which increase the animal Appetite of Thirst.

Now comes a description of the blunt-nosed viper (*Vipera ammodytes latastei*) which Owen confuses with the smaller horned sand viper (*Cerastes cerastes*) of the same region:

The Ammodytes is a Serpent very venemous and fierce, of a sandy colour, black Spots, and of about a Cubit long. The Wound given by the Female, the weaker Vessel, is said to be most dangerous: Its jaws are larger than the common Vipers, and from some Eminencies upon the Head, like a Tuft of Flesh, is called Cornutus. Its Wounds prove fatal without a speedy Cure. It is found in Lybia, a Limb of Africa.

The *Cerastes* is a Serpent of the viperine Kind; its Head resembles the Cornigerous; it belongs to the Lybian and Nubian Family: Its Teeth are like those of the Viper, and it brings its Successors into the World after the same manner. Its Constitution is very dry, which refines and exalts its Poison, and makes it more dangerous; the Wound is generally attended with Distraction, and continual pricking as with Needles. Some say, 'tis of a whitish Colour, others arenaceous; it loves sandy Habitations, where it often surprises the unwary Traveller: And all agree 'tis of a most cruel Nature; and therefore in some Places 'twas made the Executioner of Malefactors.

Its Wounds soon kill, if one of the Psyllian People be not immediately called in. N.B. These Psylli are a noted people of Syrenaica in Africa, endued with a natural Faculty of destroying Serpents upon sight, and curing their Wounds by a Touch of the Hand. . . .

And we learn that Cato:

. . . had in his Army a Number of those Natives called Psylli and Marsi, the supposed Aversion of Serpents, . . . It is said, these Psyllians inchanted Serpents, who fled at the sight of them, as if their Bodies exhaled some corpuscular Effluviums that were most offensive to Serpents, and put them into such pain that made them run. To these, the General added another Set of Persons, famous for curing the wounded by other Methods; and all little enough, Serpents being the Lords of the Country through which they were to pass.

Where the River Bagrada is I can not say; it is possibly in the country of the Bagara tribe, Sudan, where elephants and pythons occur; but even the most indulgent reader would have difficulty in swallowing the following. Owen, referring to the strength of snakes, writes:

A certain Number is sent out with little Bodies; others are of monstrous Bulk, and capable of making the strongest Efforts against all the Attempts made to destroy them; yea; are strong enough to contend with Elephants, the greatest of Animals and conquer them. *e. gr.* Attilius Regulus, the Roman General in Africa, is said to encounter a Serpent in that Country, of vast Strength and Stature, near the River Bagrada, 120 Feet long, which he and his Army could not subdue, without discharging all their Engines of War against it; and, when conquered and flea'd, its Skin was conveyed to Rome in Triumph. . . .

The Ethiopian Dragons just mentioned, have no proper Name, and are only known by a Periphrasis, *viz.* Killers of Elephants. The Method is, by winding themselves about the Elephants Legs, and then thrusting their Heads up their Nostrils, sting them, and suck their Blood till they are dead.

Presently we find Owen relating how various tribes resort to eating even poisonous species with impunity:

In the Kingdom of Congo in Africa, the Negroes roast the Adders, and not only greedily feed upon them, but esteem them as a most delicious Food.

The Circulatores, or Dealers in Serpents, devour'd at their Tables even their Heads, and pour'd the Gall into their Cups when they drank, laughing at their Neighbours Timidity, who transform their Imaginations into Bug-bears.

and rightly concludes:

That Poison is not so dangerous, if it does not mix with the Blood. Even that venemous Liquid may be tasted, yea, and swallow'd without mortal Effects, say some of the Learned. Hence it is, wounded Persons have been directed to get the Venom immediately suck'd out, which has been practis'd without ill Consequences to the Sucker. For this Method of curing venemous Wounds by Suction, Avicenna, an old Arabian Philosopher and Physician, is quoted; who says, that those who suck the Poison are in no danger, so their Teeth be sound and perfect, and their Mouths be free from all Ulcers. At Rome was an Order of Servants, whose Office was to suck venemous Wounds, which they did with Safety and Applause.

As we read the account of the King of the Serpents one is apt to conclude that Owen is confusing cobra and basilisk until we see his enchanting illustration, for, apart from its eight legs, the figure is evidently intended to represent a chameleon, whose casque or helmet has been interpreted as a crown.

But 'tis most probable, that the royal Stile is given to this Serpent, because of its majestic Pace, which seems to be attended with an Air of Grandeur and Authority. It does not, like other Serpents, creep on the Earth; which if it did, the sight of it would not be frightful, but moving about, in a sort of an erect Posture, it looks like a Creature of another Species, therefore they conclude 'tis an Enemy. Serpents are for Uniformity, therefore can't endure those that differ from them in the Mode of Motion. 'Tis said of this Creature, that its Poison infects the Air to that Degree, that no other Animal can live near it, according to the Tradition of the Elders famous for magnificent Tales. These little Furioso's are bred in the Solitudes of Africa, and are also found in some other Places, and every where are terrible Neighbours.

Following some substantially accurate descriptions of a chameleon's tongue, we come to an engaging account in which the biting possibilities of its blunt little teeth are extolled in a way to shame even the most flamboyant reporter of today:

. . . 'tis about a Foot long and spotted, has large Eyes starting out, the Tail has several white Rings round it, and its Teeth sharp, and strong enough to penetrate an Armour of Steel: it has a slow Motion, but where it fastens, 'tis not easily disengaged. . . . It frequents Cairo, and other Places, is found among Hedges and Bushes; mutes like a Hawk; swallows everything whole. It moves the Feet of each side alternately, but runs up Trees very fast, and lays hold on the Boughs with its Tail. Leo and Sandys say, the Neck is inflexible, and it can't turn without moving its whole Body: the Back is crooked, the Skin is spotted with little Tumours: the Tail long and slender, like that of a Rat; when it sucks in the Air, its Belly swells, whence some think that the Air is part of its Food. One Author says, it subsists only upon Air; another says, 'tis a vulgar Error.

With the object of settling this point:

A Certain curious Gentleman made the following Experiment, when he lived at Smyrna, in Asia-minor: He bought some Cameleons, to try how long they could be preserved alive under Confinement; he kept them in a large Cage, and allowed them the Liberty to take the fresh Air, which they suck'd in with pleasure, and made them brisker than ordinary. He never saw them either eat or drink, but seem'd to live on the Fluid in which we breathe.

After all the Gentleman's Care about 'em at Smyrna, all of them died within five Months; and having opened the Female, found thirty Eggs in her, fasten'd one to another in the form of a Chain. . . . The Cameleon is an oviparous Animal. J. Jonstonus says, it has above a hundred Eggs, from Piereskius, who nursed a Female on purpose to make Observations upon the Subject.

And finally, while on the subject of eggs the following interesting description of incubators is included:

In some Parts of Asia, and at Grand Cairo in Egypt, they hatch their Chickens in Ovens; each Oven contains several thousand Eggs which the Country brings in, and have their Eggs returned in Chickens. By this Method, they generally want some integral Part, as an Eye, a Claw, etc., which may be owing to a Want of equal Impression of Heat, tho' the artificial Warmth be continued. There are Thousands, yea Millions at a Batch, thus produced in Egyptian Ovens;—and may as well be in Europe, if our Bakers had the knack on't.

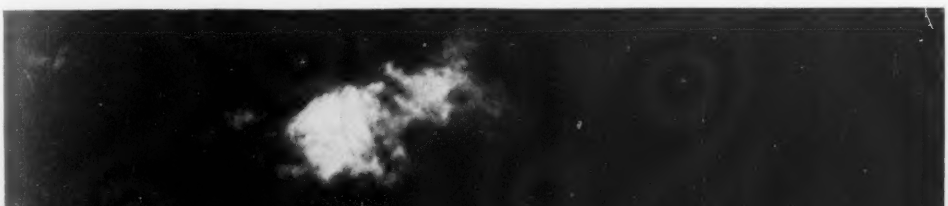
THE CCC AND AMERICAN CONSERVATION

By Major JOHN D. GUTHRIE

FORMERLY GENERAL INSPECTOR, CIVILIAN CONSERVATION CORPS

THE great adventure of American youth in the conservation of this country's resources ended on June 30, 1942. It lasted for nine and one-third years—less than a decade. Obviously, the neglect, waste and destruction of many generations could not be repaired or restored in a decade, but a heartening start has been made by the CCC. In that short time the Civilian Conservation Corps wrote its name into the economic, social and educational history of this country; it did even more than that—it started a change in the landscape of a nation. Maybe the CCC has taught America a lesson in real national thrift, which is another name for conservation of natural resources.

Although a global war was not in the national picture when the CCC was started, by 1939 National Defense had come in, and by 1941 War had entered. Conservation of natural resources is important to a nation at all times, but in days of war it is vital. The CCC did not come any too soon. It shoved forward the conservation of our natural resources by many years; many felt there was still



THE CCC—AN ARMY WITH SHOVELS

THEY WERE TAUGHT RESPECT FOR THE FLAG AND GOOD CITIZENSHIP

need for such an agency, to serve as practical work and health training centers for youth under draft age. When war ceases, the need will be increased tenfold.

The conservation picture of this country has too long been a dark one. That picture was strikingly painted in 1940 by Henry A. Wallace, now Vice-President, then Secretary of Agriculture, in these words:

> Thoughtlessly we have destroyed or wounded a considerable part of our common wealth in this country. We have ripped open and to some extent devitalized more than half of all the land in the United States. We have slashed down forests and loosed floods upon ourselves. We have torn up grassland and left the earth to blow away. We have shallowed and befouled our creeks, rivers, and other living waters. We have built great reservoirs and power plants and let them be crippled with silt and debris, long before they have even been paid for.

Out of a realization of the waste of natural resources and of the waste of idle youth, President Franklin D. Roosevelt, in 1933, combined the two into one of the most constructive programs this country has ever adopted. He had long been convinced of the urgent need to check the heedless waste of our natural resources, and when the depression furnished idle manpower, he seized the opportunity to remedy both. It was a bold stroke of conservation statesmanship. However, it was obvious that President Roosevelt had given much thought to this use of idle labor in the cause of the country's natural resources. It was no overnight idea, for even in March, 1933, less than a month in the White House, he surprised a group of less imaginative foresters, park executives, naturalists and conservationists with details of what kinds

of forest, soils, park and stream improvement work should be done and how it could be done, and he drew for them a specific organization chart. After the announcement of these advance plans, he wanted action—immediate action—and he got it. In less than three weeks after Congress passed the Emergency Conservation Work Act of March 31, 1933, he had the first CCC camp set up and working in the George Washington National Forest in Virginia. By July 1, 1933, there were 232,000 youths and veterans at work for natural resources, and by September, 1935, there were over 500,000 CCC boys in over 2600 camps distributed throughout every state, and in Alaska, Hawaii, Puerto Rico and the Virgin Islands. In 1942 the President recommended the continuation of a reduced Corps to be used as a nucleus for a post-war youth labor organization, but Congress abolished the CCC on June 30, 1942, setting June 30, 1943, as the final liquidation date. The last camp, at work on an Army airbase, was closed on August 12, 1942. During the life of the agency, a total of 2,965,959 juniors (ages seventeen to twenty-three) and 189,165 war veterans were enrolled in the Corps.

The Civilian Conservation Corps charted more than a gigantic program of conservation of the natural or renewable resources of this country. It charted effective cooperation between four executive departments; it charted a plan to help youth by the most effective and practical method—to give it worthwhile outdoor work to do, to require an honest day's work of each youth, with no semblance of the dole or "made work." And it should be emphasized that the CCC returned to the American people fair value for what it paid these youths and veterans. It was healthful work in the outdoors, out in the forests and parks and on the soils of this country.

The CCC set a new pattern for the most practical kind of education for

A CCC CAMP STREET IN THE APPALACHIANS

CCC YOUTH PLANTS A YOUNG PINE TREE

youth yet found in this country; it gave youth serious, worthwhile outdoor jobs to do—real work day by day—jobs which had to follow blueprints and specifications, jobs which when done were inspected and had to stand up. Here was no make-believe, no playtime work. Youth responded. They could see the sense of what they were doing, they could see progress day by day, and soon there came a pride in worthwhile work well done. They were doing a man's work. They were learning the *how* and *why* of work for conservation; they learned proper work habits and proper work attitudes. It was not office nor "white collar" work, it was work on the land. As Dr. Paul T. David says in *Youth and the Future* (American Youth Commission), "The physical organization and character of the CCC has been determined from the first by the nature of the work to be done. Conservation work cannot be done in a workshop; it has to be carried on at the points where the natural resources in need of conservation are located."

These boys came to realize that it was for *their* country, for the good of the whole people; it was not only the finest kind of education for any and every American youth, but it was also the finest kind of training in citizenship. It was essentially public service work. The Corps set a pattern in the practical teaching of youth which it is believed is going to have far-reaching effects on the American system of education; it was education through daily conservation work; it was learning-by-doing. The CCC between 1933 and 1942 proved this pattern was workable.

The average American was a strong supporter of the CCC, but he had little

conception of what the CCC actually did for the conservation of his country's natural resources, or how much the Corps did for youth itself. The variety of work was great and total accomplishments were stupendous. The job lists and the statistics were staggering but without interpretation they meant little to the average citizen.

The CCC left the nation a vastly improved natural resources balance sheet. This record carries such items on the asset side as hundreds of millions of young trees planted, over 100,000 miles of truck trails built, many thousands of miles of telephone lines laid, hundreds of new state parks developed, millions of acres of farm lands benefitted through erosion control and the rehabilitation of drainage ditches, better grazing conditions on the public domain, and an increasing wildlife population. The present and future value of the work completed was estimated as having a present and future value of $2,000,000,-000.

LEARNED THE DIGNITY OF LABOR

Now that the CCC has been finally liquidated, what do the figures on conservation accomplishments mean in terms of national security, national welfare and the future? The truck trails built, the fire towers erected, the telephone lines laid and the fire prevention

GATHERING TREE SEED IN SOUTHWEST VIRGINIA

and fire hazard removal work completed meant that on June 30, 1942, the United States had a far stronger forest fire prevention and suppression system than this country had ever had before. It meant that at a time when the Nation faced possible incendiary bombing attacks on its vital forest and other natural resources, the country had the truck trails, the fire towers and the communication systems necessary to combat them. The erosion control work done in the dust bowl and on southern, middle western and western acres of lands which were bare and unproductive ten years ago are now green with growing trees planted by the youngsters of the Corps. The millions of man-days spent by CCC enrollees on the forest fire front lines since 1933 mean that today this country has millions of acres of growing and mature timber which otherwise would have been destroyed. The work done on park lands means that the capacity of our recreational areas to accommodate visitors has been increased by millions.

WHAT THE CCC FOUND ON THE TVA

lands means that at a time when the Nation's food production machinery may be taxed to capacity, it has 40,000,000 acres capable of producing much more food than would have been possible had the Corps not been organized. It means that the West, which produces the bulk of the beef, wool and hides needed for victory, has more water and more grass because of CCC grazing control and range water conservation work.

The trees planted by the Corps meant that over two and two-thirds million

Some Conservation Details

Let us look in some detail at a few of these conservation results from the CCC. The CCC put in 6,459,403 man-days on fighting forest fires. What does this huge total of man-days of work mean? It means, among other things, the hardest kind of work; it means danger from falling limbs and burning snags, or being surrounded by fire—and perhaps burned to death—as forty-two CCC enrollees and five foreman were in the past nine years. It means fighting forest fires

hour in and hour out, day and night. It means that the mere boys of the CCC fought fire on a thousand fronts, to save vital American resources badly needed right now in the World War. Two CCC enrollees and three foremen were awarded the American Forest Fire Medal for heroism in fire fighting, four given posthumously. The annual average acreage burned over dropped by 27 per cent. when the CCC got out on the forest fire line. They saved forests for human needs by preventing their going up in smoke and flame; the records of both the U. S. Forest Service, the State forest services and the National Park Service show this.

The CCC boys set out some two and two-thirds billion tree seedlings. What does the planting out of 2,688,527,000 young trees mean? It means that nearly three million acres of otherwise barren, denuded or unproductive land now have a chance to grow timber for human needs, or for human enjoyment, or to help stop valuable soil from washing away, or to shelter and protect wildlife. Many of these young trees will be ready to harvest by the sons and grandsons of these CCC boys. Trees grow slowly; the CCC was planting for the future. It also means that the seed from which these young trees sprang had to be collected, and sown in forest nurseries. And the CCC spent 6,111,258 man-days in preparing land, sowing seed, weeding, transplanting, watering, and tending these two billion young trees before they were ready to be set out on the two million acres. Many millions of America's denuded acres yet remain to be planted, to make them productive. And back of all this, the CCC had to collect 875,970 bushels of conifer seed and 13,634,415 pounds of hardwood and other seed to plant in the nurseries to grow the seedlings to plant on the barren soils.

WHAT THE CCC LEFT ON THE TVA

Also the forests on some four million acres have been improved and bettered by having the poorer, crooked, diseased trees cut and taken out, thus giving more light and moisture to the trees remain-

MILLIONS OF ACRES ARE NOW GREEN BECAUSE OF THE CCC

ing. This is a permanent improvement, a real forestry investment; foresters call it "timber stand improvement." The material removed went into fuel wood, poles, fence posts, guard posts and charcoal. Forestry foremen supervised this stand improvement. At least four million acres of American forests are in better condition because of the CCC boys.

The boys built 126,230 miles of truck trails and minor or forest roads, and in addition, they maintained 580,995 miles. Of what benefit are all these miles of road? It is helping fire crews to get to forest fires while they are still small and while there is a chance to stop them, or put them out. This road mileage opened up new forest and park areas for use of the timber and other resources, or for public recreation and enjoyment. The 88,883 miles of telephone lines they built also give quicker action on fires and help in better administration of forest and park lands—federal and state. Many a mile of these CCC roads is now helping in better protection of the country.

Forests are also killed by enemies other than fire. The annual toll by fungous diseases and forest insects is silent, steady and enormous. The insect and fungous attacks on the forests go on, through peacetime and wartime. Blister rust kills the white pines in the Northeast and in the Northwest. To check or control tree and plant diseases, the CCC worked on 7,955,707 acres. Besides, forest and other insect pests—like pine and bark beetles, spruce sawfly—Mormon crickets and grasshoppers were checked or controlled on 6,161,742 acres.

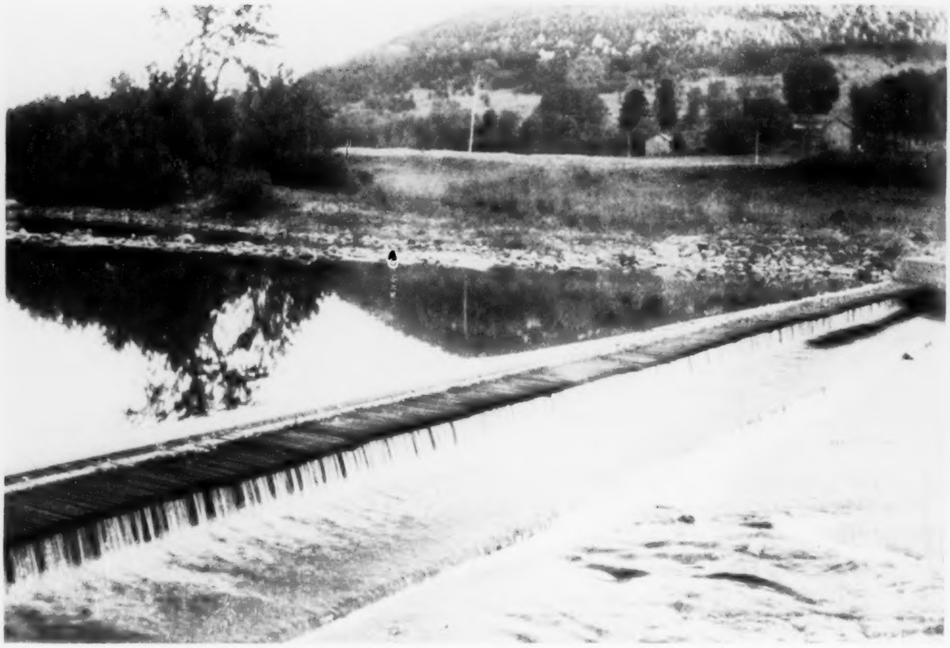
For many years before the CCC came, the soils of this country had been washed, and were still being washed away, going down millions of gullies, clogging small streams, creeks, rivers and harbors with silt, mud and debris. The invaluable topsoil of the nation was being lost forever. Not only topsoil fertility, but also the soil itself was being lost. And the tragedy of it was that it could have been prevented. Millions of acres had been abandoned as farm land. We talked of marginal and submarginal

farm lands, rural slums, share-croppers, farm migrants, "the ill-fed, the ill-housed and the ill-clothed." The CCC came, and provided manpower to do something practical about this vital soil problem.

Soil salvage work was done in forty-five states, stretching from coast to coast. Soil erosion control meant doing many different jobs. Some of the more important were: check dams, seeding and sodding, tree planting, diversion ditches, terracing, channel outlets, water spreaders, quarrying, contour furrows and ridges, road and wind erosion treatment. Accomplishments on these run to large figures, but pretty small in the picture of what was needed to be done, and what remains to be done. For example: 318,076 permanent and 6,341,147 temporary check dams were built; 33,087 miles of terraces were put in; 431,321 outlet structures were built; 638,473 acres were planted to stop sheet erosion. During its nine years of existence CCC accomplished erosion control on more than twenty-five million acres, but this is only a start on the millions of acres needing attention. This is essentially farm land, though much erosion was controlled on Western grazing lands. Today in these war times this improved land is better able to do its share in the farm battle to out-produce the Axis; this fact is due in no small part to the CCC in starting the protection of our most precious natural resource—the soil.

Grass or forage is an important natural resource throughout the West, the Middle West and the South. Sheep and cattle must have forage and water, especially on the semi-arid ranges of the West. Often grass, weeds and other herbage are unusable because there is no, or not enough, water, or the water is too far from the forage. This means poor distribution of stock, unused range or overgrazed range. To help this situation on national forest, public domain and Indian reservation range, the CCC improved 12,346 springs by damming or otherwise piping water, 3,311 waterholes, and built 9,805 small reservoirs, or what the Western stockmen called "tanks."

THE BOYS CLEANED UP AFTER THE NEW ENGLAND HURRICANE



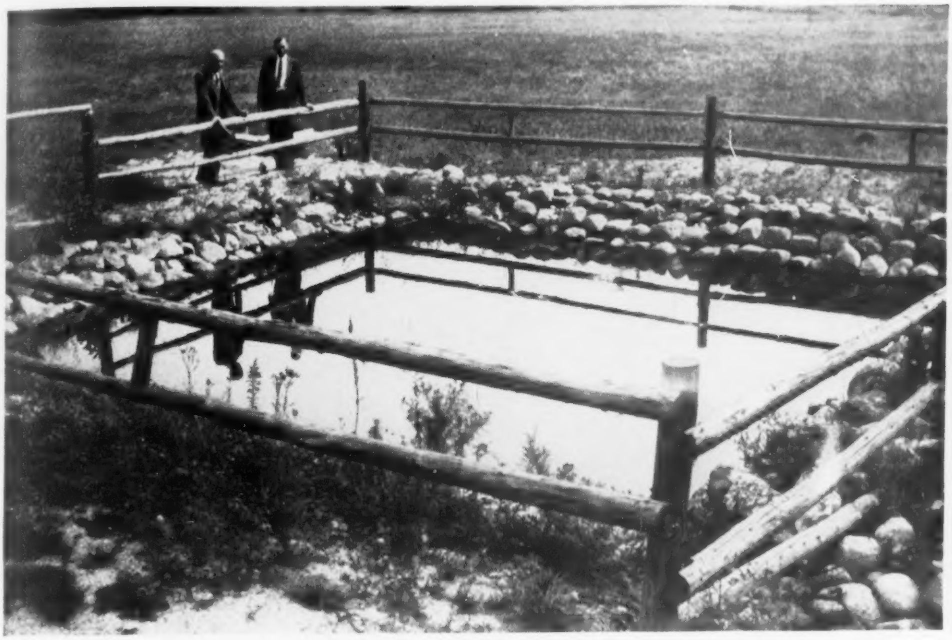
THEY IMPROVED STREAMS FOR FISHING

These range improvements mean better and more stock, and beef, mutton, wool and hides, all of which are needed more in wartime than in peacetime.

Americans have become more and more an outdoor people, especially during the past two decades. More and more folks go hunting, fishing, hiking, mountain climbing, skiing, camping or just picnicking. This has meant, among other things, better knowledge of the outdoors, of nature, a broader understanding, better health and better citizens. Good roads and the auto have helped to bring this about. The CCC recognized this fact of American life and built camping spots, picnic grounds, overnight cabins and other outdoor life necessities all over this country. The Corps did landscaping on 233,793 acres, developed 52,319 acres as public campgrounds. It developed 10,398 acres as public picnic grounds. These new developments were widely distributed, in the high mountains, in the foothills and along the seacoasts; they are accessible to the American people.

State parks came into their own through CCC work; 704 camps devoted most of their time to these projects. Just a handful of states had any state parks prior to 1933, and those states having parks were able to improve, increase, and develop other areas by CCC labor. Now every state has some state parks. State, county and municipal park work was done by the CCC in forty-seven states, thirty-five counties and seventy-four municipalities. Not only was needed work done on ninety-seven units of the National Park and Monument areas but restoration was carried out on 3,980 historic structures, while to insure accuracy in this restoration work a total of 9,005,407 man-days was spent in necessary reconnaissance and archaelogical investigations by CCC enrollees.

The CCC helped to give wildlife a place in the sun. The Corps built 4,622



THEY BUILT WATERHOLES IN NEW ENGLAND FOR FOREST FIRE PUMPS

fish-rearing ponds, worked on fish food, cover planted and seeded on 112,912 acres, developed 6,966 miles of streams for better fishing, and stocked streams, ponds, lakes and reservoirs with the enormous number of 972,203,910 fish or fingerlings. The CCC spent 116,384 man-days on wildlife feeding and built 32,148 wildlife shelters. They developed large and small wildlife and game reservations—some brand-new—and enlarged and improved older ones. They made game counts and helped mightily on game and wildlife surveys. Through Emergency Conservation Work funds, lands for many new wildlife areas were bought and older ones enlarged. They planted trees and shrubs on over two and one-half million acres, much of which will serve as habitats or refuges for wildlife. They kept forest fires from destroying wildlife habitats and sanctuaries and even wildlife itself, all over the country. And yet there were uninformed critics who said the CCC was ruining the game and wildlife of this nation.

In addition to all the above work, the boys did many miscellaneous jobs. They built eighty emergency airplane landing fields, 116 radio stations, 532 landing docks and piers; they fought coal fires on public lands in Wyoming for 201,739 man-days; they marked 35,442 miles of forest, park, and other land boundaries. During 1941 and 1942 there were 156 CCC companies doing needed national defense work on ninety-two military reservations of the country, thus relieving new soldiers so they could be trained for combat service. And with all the above they spent 2,079,440 man-days on emergency work. And what might emergency work be? It was work, hard work, on floods, saving people, homes, furniture, chickens and livestock; it was helping clean up and helping stricken humanity after hurricanes and tornadoes; it was looking for and rescuing persons lost in the mountains or forests; it was

BUILT BIRD FEEDING STATIONS

rescuing prospectors, miners, and sheep and cattle during unusual blizzards in the West. Some forty CCC camps put in almost two years in cleaning up the debris and making safe from fire the forests of New England after the big hurricane of 1938. Two enrollees were awarded the CCC Certificate for Valor for heroism on forest fires, six received the Award for outstanding work on floods, and twenty-four for heroic rescues of drowning persons. Whenever or wherever there were great disasters or emergencies, the CCC was always called on—and they always answered, with supplies, food, and ready and willing hands, arms and backs.

These are just a few CCC accomplishment statistics, perhaps meaningless to the average American, but to foresters and other conservationists they stand for the greatest boon ever to come to conservation in this country. When transplanted to the forests, soils, parks, waters and wildlife of the United States—out of a report and onto the ground—these CCC statistics are full of meaning for the future of this nation.

Moreover, not only has the CCC taught three million youths through daily practice something of what conservation is, but it has also brought to the American people a better idea of conservation. Conservation has become a household word. The CCC also gave a new meaning of the word to foresters, soil scientists, naturalists and other conservationists. In dollars and cents the value of the work done by the CCC for conservation of natural resources of this nation, in the little more than nine years of its existence, has been conservatively estimated to be well over $2,000,000,000.

The Corps built up the bodies and minds and morale of nearly three millions of young Americans against a day of need—which is now—and made them better able and more willing to fight for their country.

Almost three million young Americans served in the CCC between the ages of seventeen and twenty-three and thus were of draft age. Because of this fact, it is estimated that there are probably two and a half million of them now in the armed forces of the nation; the other half million are probably serving in war industries. Thousands of CCC foremen and technicians are now in our armed forces. The CCC also gave invaluable training to thousands of regular and reserve officers (60,000 reserve officers served in the Corps) against this same day of need. There are thousands of men now better Army officers and many hundreds of thousands of youths now better non-commissioned officers and soldiers because of their training and experience in the CCC. They are better citizens, better Americans, because of the CCC—and America is a better place to live in because of the CCC.

VINCENNES: HISTORIC CITY ON THE WABASH

By Dr. ALDEN CUTSHALL
DEPARTMENT OF GEOLOGY AND GEOGRAPHY, UNIVERSITY OF ILLINOIS

The character and personality of Vincennes are expressed in the contrast between two buildings standing within a hundred yards of each other and located just southwest of the approach to the new Lincoln Memorial Bridge spanning the Wabash River. The first is the old Catholic Cathedral, one of the most interesting historic landmarks of the Mississippi Valley (Fig. 1), which has watched the growth and varying fortunes of the city for more than a century (1826). This church, together with the old French burying ground within the churchyard, is representative of a frontier community, yet it has persisted within a few blocks of the business area and thereby lends a picturesque atmosphere to that section of the city. Nearby is the other building, the colorful, columnar George Rogers Clark Memorial of modern architecture and design, which stands in a beautiful, landscaped plaza overlooking a broad curve of the river (Fig. 2). The latter structure appears oddly out of place in that portion of the city which contains principally architectural types of the last century, nevertheless it represents a spirit of renovation of the urban scene and a tardy civic advancement which appears very much in evidence throughout the community.

A River Site

The attachment of a nucleus of population to some riverine site was not at all unusual in frontier America, but the early history of Vincennes is directly related to the military history of the area as well as to the commercial advantages of a river location. Its origin was marked by the establishment, in 1702, of a French fort and trading post on the east bank of the Wabash River, 120 river-miles north of the Ohio River[1] (Fig. 3). The location chosen was a river crossing, a junction between the Wabash route and a trail leading from the Falls of the Ohio to the St. Louis and Kaskaskia settlements. Immediately north of the city the river swings to its eastern bluff, cutting between the Robeson Hills and the Indiana uplands a mile to the east, and then winds its way southward to join the Ohio, following a more middle course through the fertile sandy flood plain (Fig. 4). This valley plain, about ten miles wide a short distance south of the city, is really a broad alluvial tract that is the product of the Wabash and two of its tributaries, the Embarrass and White Rivers.

The immediate site of Vincennes is a Maumee gravel terrace of about a mile in width, extending as an irregular tongue-like projection between the river and the eastern sand hills and bluffs. This terrace rises a few feet above the flood plain, but its lower portions have been subject to overflow in cases of unusually high water. A sea-wall and newly constructed levee will supposedly remove this flood hazard in the future. Except for the leveling of a few historic Indian mounds upon the terrace, no particular building problems have been encountered. Back of the terrace small tributary streams of a dendritic pattern have dissected the loessial covered upland into mature valleys and ridges of relatively moderate relief. Beyond this gravel remnant, the streams have worked their way through the loessial material that borders the edge of the flood plain and some poorly-drained areas are in evidence upon the broad bottom lands.

[1] An unnamed trading post was established as early as 1680, but its permanency is subject to question.

FIG. 1. OLD CATHEDRAL CHURCH
STANDS ON THE SITE OF THE EARLIER ST. XAVIERS LOG CHURCH AND IS SURROUNDED BY AN OLD FRENCH CEMETERY WITH WEATHERED MARKERS.

Although Vincennes was originally a river port of importance, that has long since ceased to be the case. Very little river traffic has existed on the Wabash for more than fifty years and none has been recorded at Vincennes for at least a quarter of a century. The commercial core has expanded to the east and only the older manufacturing plants and secondary structures occupy river-front locations.

The Early City

Vincennes, named after its founder, Frances Morgan De Vincenne, was established as a fort to guard against the encroachment of the English into the territory. A permanent mission dates from the construction of the fort and the community existed in this dual capacity until the territory east of the Mississippi was awarded to England under the terms of the Treaty of Paris in 1763. Then the region was under English domination until captured by George Rogers Clark during the War of Independence. The first houses erected around the fort were timber structures, thatched with straw, and plastered with adobe. These cabins were built in "long zig-zag lines with broad verandas and narrow streets between." In 1800 a register of the federal land office was established in this district and the same year Vincennes was made the capital of the vast Indiana Territory with William Henry Harrison, afterwards President of the United States, the first Territorial Governor. Governor Harrison's residence, built in 1804 in the style of a Virginia plantation home, was the first brick house in the city and has been retained as an historical shrine and museum. The territorial Legislature Hall, a tiny, two-storied frame building of pioneer architecture, once the seat of the capital of a region greater than the original thirteen colonies, has also been preserved and stands among the maples of Harrison Park.

The fort remained in good condition until 1816, when it was razed and most of the lumber subsequently used in the erection of smaller dwellings, the greater number in the western portion of the village. In the first part of the nineteenth century many handsome brick residences lined the river front a short distance upstream in the vicinity of the present Harrison Park. The select residential section of the last century extended along the higher ground from this area of river homes to the Court House on Seventh Street. During the building boom of 1888 to 1901 many of the older homes of this section were replaced by dwellings of a more modern architectural design.

The early inhabitants usually followed agricultural or commercial pursuits, the French land grants having divided the prairies around the village into "small slips" so that each proprietor had a frontage on the Wabash River. Individual farmers floated their surplus products downstream to the New Orleans market or, more often, a village storekeeper served as middleman, col-

FIG. 2. AIR VIEW OF THE GEORGE ROGERS CLARK MEMORIAL
ON THE SITE OF OLD FORT SACKVILLE. VIEW SHOWS THE WABASH RIVER, LINCOLN MEMORIAL BRIDGE, THE OLD CATHEDRAL WITHIN THE FRENCH BURYING GROUND, THE LIBRARY AND SMALL BRICK CHAPEL USED BY STUDENTS IN THE OLD COLLEGE OF VINCENNES AND ST. CLARES CONVENT.

lecting the products of the area and transporting them down the Mississippi. The necessities that could not be produced in the frontier community were sometimes brought to Vincennes on the return trip from New Orleans but, in most cases, were carried overland from Cincinnati or Pittsburgh or were floated down the Ohio and poled up the Wabash.

The Present City

The growth of Vincennes has not been as rapid as that of Terre Haute or Evansville, but its population doubled between 1870 and 1930. It increased gradually until 1900, then more sharply until 1920, but has experienced a retarded growth during the last twenty years (Table I). This continued increase has been, in part, the result of a renovation of community spirit, which has been largely responsible for the increased commercial and industrial ac-

TABLE I

Population Growth of Vincennes

Date	*Population*
1850	2,070
1860	3,860
1870	5,440
1880	7,680
1890	8,853
1900	10,249
1910	14,895
1920	17,166
1930	17,564
1940	18,228

FIG. 3. LOCATION OF VINCENNES

tivity of the city. (It was not until almost 1900 that modern industries were attracted to Vincennes.) At the present time there are more than fifty industrial and wholesale plants, the majority being small community or service industries. Of the remainder, three manufacture straw-board paper and kindred products and two manufacture glass. Other important industrial concerns include a shoe factory, a plant making structural steel bridges, a wholesale bakery, a creamery, and a canning factory (tomatoes, apple products and pumpkins). The bridge plant and the window glass company have been located in Vincennes since the turn of the century, but the other major establishments have a shorter history.

Vincennes also is a major center of distribution. The wholesale bakery and creamery have been mentioned, the latter having sales branches in some half dozen cities within a thirty-mile radius of the parent processing establishment. An ice and cold storage company has a similar but more extensive system of plants in southwestern Indiana and adjacent Illinois. Wholesale grocers, distributors of bus bodies, mill products, bottled beverages and beer, and the work of the various commission men are indicative of the wholesale phase of the city's economic structure.

Agricultural and Mineral Attachments

Vincennes' early development was based upon a riverine location and the abundant fertile agricultural land of the lower Wabash plain. Later growth has been more closely associated with the nearby mineral deposits along with certain cultural factors.

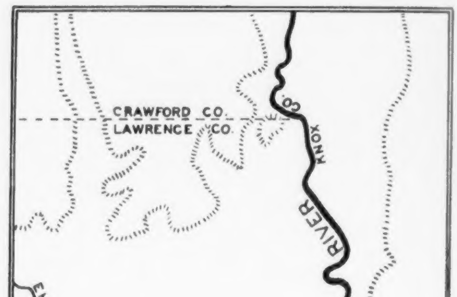


FIG. 4. THE WABASH RIVER
ITS FLOOD PLAIN WIDENS NOTICEABLY NEAR VINCENNES, BECOMING A BROAD ALLUVIAL FLAT.

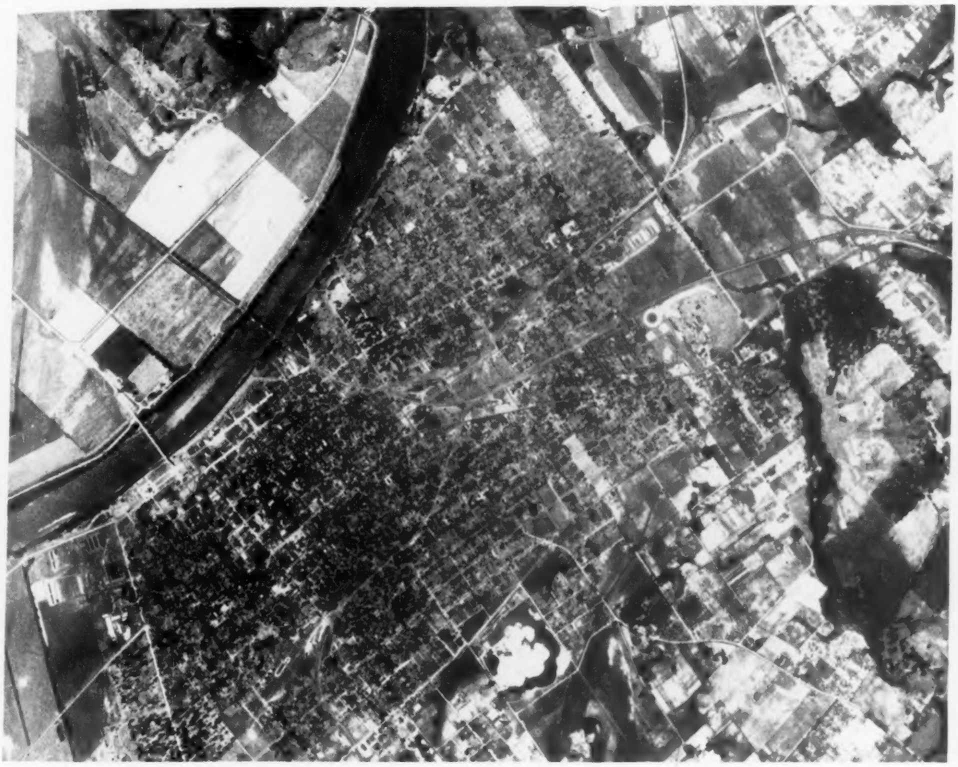


FIG. 5. AIR PHOTOGRAPH OF VINCENNES AND ENVIRONS
SHOWING THE RICH FIELDS OF ADJACENT ILLINOIS AND ORCHARDS EAST OF THE CITY.

Vincennes is situated in the heart of a prosperous farming region, Knox County, Indiana and Lawrence County, Illinois, being directly tributary to the city. Much of the land in these counties, as well as that in Gibson and Wabash Counties directly to the south, is composed of a fertile, sandy, flood plain soil. This soil is found in the first and second bottoms of the larger streams and parts of it are low and swampy, necessitating artificial drainage. It is a tract of cash grain farms in a mixed farming region with wheat and corn the principal crops. The wide expanse of flat bottom land is broken by numerous sandy knolls and ridges, in reality terrace-like remnants of sandy outwash material which are often planted in melons, tomatoes, or sweet potatoes. The famous orchards of Knox and adjacent counties are located on the rolling sand hills (dunes in many cases) at the edge of the upland (Fig. 5). The upland portion of Knox County is composed of smooth rounded hills with soft silt six feet or more in depth. Wheat, corn, and general farming are practiced on these interfluve areas. Vincennes is connected by rail and highway with metropolitan areas, so it is noted for the shipment of grain, livestock, fruit, and vegetables to the city markets, while local mills and canning factories are a response to the agricultural environment. The importance of agriculture in Knox County can best be illustrated by the fact that, in terms of the value of agricultural products, it is in tenth position in Indiana, and the only one of the leading counties that is in the southern third of the state. It ranks first in wheat acreage and in peach pro-

FIG. 6. THE CITY HALL
OLD RED BRICK BUILDING ON MAIN STREET.

duction. It ranks second in number of apple trees, second in vegetable production, third in tomato production, and is the fourth corn producing county.

Two important mineral fuels (coal and petroleum), along with numerous non-metallic construction minerals of less importance, are found near the city of Vincennes. Coal has been mined within the corporate limits but the present commercial mines of Knox County are a few miles east of the Wabash River, many of them near Bicknell. Coal is an important product in all the counties of western Indiana, Vigo, Pike, Sullivan, Knox, and Greene ranking in the order named. Indiana coal is low grade bituminous, its fuel ratio ranking slightly below that of the coal from southern Illinois and western Kentucky.

The older petroleum fields of southeastern Illinois and southwestern Indiana, developed in the early years of the present century, are located to the south, west, and north of Vincennes. These fields also supply natural gas to the cities of the area and the presence of cheap, clean fuel led the Blackford Window Glass Company to locate at Vincennes in 1901. The oil refineries of Lawrenceville and Robinson, Illinois, are only a few miles away. The recent petroleum development in the Illinois Basin, as well as further exploitation in the old fields, have pushed Illinois from an insignificant position (fourteenth) to the fourth ranking oil producing state.

Retail and Wholesale Areas

The axis of the commercial core is Main Street (Fig. 7). It includes most of the retail district which serves the urban community, the outlying rural areas, and, in part, the neighboring mining and agricultural cities. On this old thoroughfare are situated the principal retail stores, banks, office buildings, theatres, and the city hall (Fig. 6), which is a center of municipal importance in any American city. It is characterized by buildings of two or three stories in height, although this general level is exceeded by a six-story office building and a half dozen intermediate structures (Fig. 8). Brick is the prevailing material with stone of secondary importance, while the architectural types are characteristic of the past century with an intermingling of more modern structures. These downtown buildings, facing each other across the narrow, crowded street, present a scene which, in its essential characteristics, can be duplicated only in the older cities of the United States.

The commercial development has expanded to include parts of the adjacent parallel streets (Busseron and Vigo) and two cross streets (Second and Seventh) more or less at the ends of the principal district (Fig. 9). Busseron Street has a few retail stores but is characterized principally by service shops, while Vigo Street has commercial structures (principally garages and service stations) interspersed among residential structures. Second Street is lined with old buildings and is a mixture of manufacturing, wholesale warehouses,

FIG. 7. MAIN STREET LOOKING TOWARD THE RIVER FROM FOURTH STREET

secondary retail establishments, and a few vacant buildings. Seventh Street connects the downtown area with the Union Station, about three-fourths of a mile east of Main Street. It is a street occupied by commercial, residential, and public structures, the latter including the Court House, Public Library, and Civic Auditorium. Probably its development has reached a point of stagnation for the only street car line leading to the eastern part of the city was removed from this street about ten years ago, and now most modern vehicular traffic follows the highway a block nearer the river.

The wholesale district occupies the older part of the city and much of it is to be found along North Second Street which was once a flourishing retail district. Since the better retail stores have moved to more desirable locations, this part of the city, for the most part, shows unmistakable signs of decadence, with a few of the buildings now unoccupied or at least only partially utilized. The buildings are of brick construction, there being a complete absence of corrugated iron sheds and other typical warehouse structures. This wholesale function of Vincennes is not a recent one, for the city has always been one of the important railway and highway junctions of southwestern Indiana.

Industrial Activity

Vincennes is and always has been a city of varied industrial activity. A century ago the flour milling and woodworking industries were of foremost importance and the city has never failed to have several representatives of the former. Flour milling reached its peak in the latter part of the nineteenth century and the early part of the twentieth, when four or five mills were in operation most of the time. The largest, Broadway Mills, had a daily capacity quoted at various figures ranging from 200 to 350 barrels, and the quality of its flour was recognized when the mill was awarded first prize at the Philadelphia Centennial Exposition in 1876. The mills of Vincennes supplied foreign as well as domestic markets during this period, and as late as 1910 much of the flour from Atlas and Emison Mills was shipped directly to Glasgow, Scotland. Meatpacking, based on locally supplied swine and cooperage and salt from southeastern Illinois, flourished prior to the Civil War, but has long since passed from the

FIG. 8. PLAZA BETWEEN FIRST AND SECOND STREETS
SOME OF THE BUILDINGS IN THIS OLDER SECTION OF THE CITY WERE REMOVED TO MAKE THE APPROACH TO THE LINCOLN MEMORIAL BRIDGE AND THIS PLAZA AREA IN DOWNTOWN VINCENNES.

industrial scene. The cooperage plants and furniture factories of the last century were a direct response to the abundant hardwood forests, but there is little saw timber left in the area and lumber products are no longer important. In the present century a rolling mill and a button factory added to the variety. The former was discontinued with the obsolescence of its equipment and the latter with the decline in the quantity of mussels taken from the Wabash River, although the recent economic depression may have been a contributing factor. The bridge plant and a small foundry are the only remaining representatives of the steel industry. The willow furniture factory recently discontinued the line and began manufacturing and distributing bottled beverages. The canning factory and a few minor establishments are seasonal in their operation and the mills are not large employers of labor; hence, the major portion of the industrial wage earners are employed in the shoe factory, the glass industry, and the paper plants.

Of these three industries, the shoe factory is the largest employer of labor. This plant is the result of the decentralization of the shoe industry and is one of many similar factories located in cities of five thousand to twenty-five thousand population within a two-hundred mile radius of St. Louis, the shoe center of the Midwest. The prime requirement for the location of these branch plants is that there be convenient transportation facilities between the city and the St. Louis warehouse of the parent establishment.

The manufacture of strawboard is not a new industry at Vincennes, one plant having begun operations in 1886 and a second in 1904, but it is only within the last two decades that the industry has become important. This increase can be traced to two factors: the increasing demand for strawboard containers and the trend from the manufacture of one major product to the manufacture of a variety of items. Twenty-five years ago egg-case board was one of the common products, but it has now become of only secondary significance. Strawboard

wrapping paper and cardboard containers are of greatest importance today, but a comparatively new product, chip paper, is becoming relatively more important. In general, the major portion of the output is marketed in the nearer large cities. The Vincennes plants are conveniently located because they have immediate access to the two principal raw materials, the wheat straw of the lower Wabash Valley and the cheap coal of western Indiana.

The principal glass factory was moved to Vincennes in 1901 solely because of the cheap natural gas that was available. None of the other raw materials has a local origin. The sand comes from Greencastle, Indiana or Ottawa, Illinois; the limestone from Bedford; burnt lime from Ohio and elsewhere; and soda ash from Detroit.

Cheap land and accessibility to lines of communication are the chief factors in determining the location of the industrial districts within the city. These conditions are found on or near the urban periphery and are, in some instances, low, swampy lands not suitable for residential utilization. One group, glass and paper, is located just beyond the southwestern corporate limit near the city drainage ditch and only a block from the river (Fig. 10). A second group is in the eastern part of the city not far from the union station and near a junction of rail lines. The third district is less concentrated and extends along the river from the downtown section to the northern limits (Fig. 11). The last named area contains many of the older establishments and, being interspersed with residences, is somewhat handicapped from the standpoint of expansion of plant capacity or loading facilities. The numerous light industries are scattered in various positions throughout the city but chiefly on the periphery of the commercial core or along the railroads.

Residential Districts

The character of the Vincennes residential areas varies with the suitability of the land and its desirability for residences. The land to the south and west of the city is low-lying and swampy, so the principal residential areas are found east of the commercial core. The select residential district of earlier days was on the higher land conveniently accessible to the downtown area. This was along North Fifth, Sixth, and Seventh Streets and the large colonial type structures remain to attest the former prestige of this section of the city. Some of these homes are currently utilized as tourist homes and the more desirable rooming houses. The newer and more select additions of the present decade are along the edge of the bluffs and several blocks from the earlier district. This area is more rugged and offers greater opportunity for beautifully landscaped

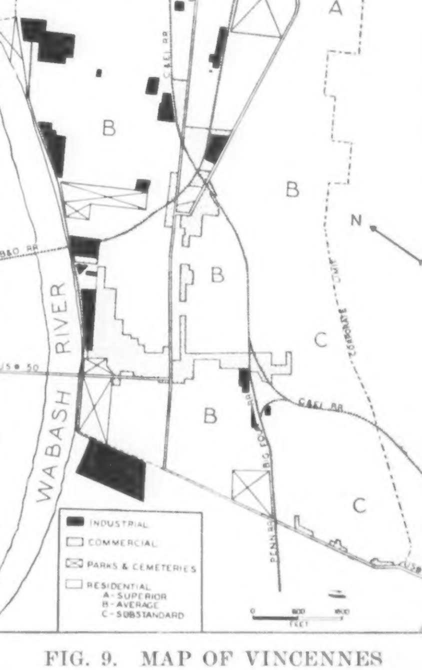


FIG. 9. MAP OF VINCENNES

FIG. 10. BEYOND THE WEST CORPORATE LIMIT
LOW, SWAMPY CONDITIONS PREVAIL. IN THE BACKGROUND CAN BE SEEN THE PLANTS OF THE FORT WAYNE CORRUGATED PAPER COMPANY (LEFT) AND THE BLACKFORD WINDOW GLASS COMPANY.

homes. It is also well away from the city proper which is the case of most recently developed subdivisions. Between the two areas is an irregular section of middle class homes. The substandard homes are found in the northern sector and in the south and southwest portion of the city, although these are usually individual homes rather than multiple dwelling units (Fig. 8). Most of the Negro families live near the southwestern corporate limit.

Most of the residential structures have not been built within recent years; in fact, there has been very little construction work at Vincennes since 1930. The major building boom was between 1895 and 1905, the period of greatest industrial expansion, when thirty-one per cent. of all residential structures were built. Thirty per cent. of the structures were built before 1895 and several are more than a hundred years old. This leaves thirty-nine per cent. that have been erected since 1905, construction gradually declining since that date.[1]

Some years ago Vincennes had a slum problem. The low land along the river in the western part of the city was the home of the mussel fishermen and appropriately named "Pearl City." It was characterized by squatter shacks and the accompanying filthiness. These homes were on the very edge of the river and subject to occasional flooding. With the decline of mussel fishing the families were destitute or near-destitute most of the time. Then, prior to the construction of the new levee, a combination municipal and private housing project was undertaken and these people were encouraged and persuaded to move into the more desirable accommodations and to seek other types of employment. A second slum area was located near the northern corporate limit but, after many of the buildings were condemned, a low-cost federal housing project, Major Bowman Terrace, was built (1940) and many of these people moved into the modern two-family units that had become available (Fig. 12).

Relationship to Larger Cities

Vincennes is related to the nearer large cities but is not solely dependent upon any one of them. According to Dickenson it is situated near the edge,

[1] *Real Property Survey*, Vincennes Housing Authority, 1939, p. 21.

but within the Chicago metropolitan region, that city being the geographic epitome of the Middle West.[2] The people of Vincennes read Chicago, St. Louis, and Indianapolis newspapers, those of the first named city predominating. Livestock shipments are sent to these same cities and also to Cincinnati, but St. Louis appears to be more important. Vincennes is within the wholesale trade territory of Indianapolis, but near the boundary of that territory with those of St. Louis and Chicago. Terre Haute and Evansville are smaller but nearer wholesale centers of importance.

FIG. 11. THE ATLAS MILLS BESIDE THE WABASH

IN THE OLD PART OF THE CITY NOW PROTECTED BY THE NEW SEA-WALL IN FOREGROUND. *Left:* THE MUNICIPAL WATER TOWER AND SLENDER SMOKESTACK OF CENTRAL FIBERS CORPORATION.

Conclusion

The prestige of the city, its traditional leadership in the region, and superior transportation facilities have combined to give Vincennes a significant position in the commercial life of southwestern Indiana. The list of wholesale firms include the distributors of groceries, petroleum products, bus bodies and equipment, feeds and flour, bakery products, lumber, and hardware. Commission men buy livestock, poultry, fruits, and vegetables from the producers and ship them to metropolitan markets. The retail merchants serve not only their own community, but also the occasional and frequent customers from neighboring cities, nearby villages, and the surrounding farming regions of Indiana and Illinois.

To summarize, Vincennes as a city possesses a unique quality that distinguishes it from most other communities of southwestern Indiana. This may be attributed to the diversified economic interests of the community, its somewhat larger size, and the ease of communication it enjoys with the other urban centers of southern Illinois and Indiana. Vincennes is not a mining community although mining has long been a major industry in this part of the state and the proximity of cheap coal has contributed to the varied industrial structure of the region. The city is within an area that

[2] R. E. Dickenson, "The Metropolitan Regions of the United States," *Geographical Review*, Vol. 24, 1934, p. 286.

FIG. 12. MAJOR BOWMAN TERRACE
A FEDERAL HOUSING PROJECT COMPOSED OF TWO-FAMILY UNITS WITH INDIVIDUAL YARD SPACE.

ranks high agriculturally, but is not a city that is dependent upon the adjacent farms and orchards for its existence. Manufacturing is important, but there is not a single outstanding industrial plant in Vincennes. In brief, it has retained its position of regional leadership because of diversified endowments and because it had the advantage of an early start. Except in a few instances, Vincennes does not depend on the surrounding rural areas which, instead depend on Vincennes, both for day-to-day and seasonal purchases.

The general impression received is that Vincennes is a center of declining importance. In some respects this is true, for the purpose of its earlier existence is gone. The small unimportant industries that are existing only because of an early start or because of some previous advantage which no longer exists can hardly be sufficient for Vincennes to retain its position as a regional center. However, there are industries, such as corrugated paper, that can be manufactured in Vincennes as cheaply as, or more cheaply than, anywhere else. Others, such as shoes, although enjoying no special advantages, can compete successfully under present conditions. It appears quite possible that, supported by moderate civic enterprise, the city need not anticipate a dark future, but can look toward continued leadership, even though on a moderate scale.

SCIENCE, EDUCATION AND CHINA'S RECONSTRUCTION

By Dr. CHI-TING KWEI

PROFESSOR OF PHYSICS, NATIONAL WUHAN UNIVERSITY

WHEN China was invaded in July, 1937, Japanese militarists boasted that we would be brought to our knees in three months. It is now fully six years and China is fighting on, more determined than ever to win the victory on the side of the United Nations. Our endurance is largely due to the far-sighted policy of our leaders to carry on reconstruction side by side with our war of resistance.

Before the war, western China was almost entirely undeveloped, as compared with the coastal provinces. Therefore, for military reasons as well as for the reconstruction of our industries, it was imperative to build up a comprehensive system of transportation, besides the existing water routes. China immediately mobilized labor, including 100,000 women in the Kansu province, to build her highways. Up to June, 1942, 79,827 kilometers (over 49,000 miles) of highways have been built, often over difficult terrain with dangerous cliffs or over ground covered with snow part of the year, as in the case of the Burma Road or the road from Loshan (Kiating) to Sichang. Two of the important lines are the Chinese Soviet Highway and the Road from Chungking to Rangoon. The former connects Chungking to Tachen via Sian, Lanchow, Sinsinchia and Urumchi over a distance of 3,451 kilometers. The total distance from Chungking to Lashio via Kunming and thence

AN OPEN AIR CLASS NEAR A TEMPORARY SCHOOL BUILDING

GIRLS OF LIANGKIANG GIRLS' COLLEGE

THESE YOUNG STUDENTS HAVE TREKKED FROM SHANGHAI TO CHUNGKING TO CONTINUE THEIR STUDIES. THEY HAVE LEARNED TO USE PICKAXES, BUILD THEIR OWN ROADS AND DORMITORIES.

over the Burma railroad to Rangoon is 3,360 kilometers.

During the war, China has extended her railways into both the north and southwestern provinces. The Lunghai Railway has been extended from Sian to Paochi and the Hsiang Kwei Railway has been completed between Hengyang, a point in Hunan Province on the Canton Hankow Railway, to Kweilin in Kwangsi Province and thence to Kweiyang in Kweichow Province. Ultimately there will be a railway running parallel to the highway between Kweiyang to Chungking, our wartime capital. With the supply of Oregon pine and rails cut off from abroad by the enemy's blockade, our engineers are working under great difficulties but with much ingenuity. Local materials are being used to the fullest extent and much of the old railways has been dismantled and transported to the hinterland just in advance of the enemy's occupation. Thus Hsiang Kwei Railway (Hengyang to Kweilin) may be considered in part as a bodily transplantation of the Cheh-Kan Railway (Hangchow to Nanchang). The railways in Free China now total 2800 kilometers.

With the loss of the coastal provinces, China's loss in industrial plants was extremely heavy, such as the sugar refinery and the salt and soda works in Tientsin, chemical factories for producing ammonia, ammonium sulphates and acids in Nanking, and numerous textile, soap, glass and rubber factories and shops in Shanghai. But a serious effort has been made to help 42,000 skilled laborers and technicians to move into the interior and to transport some 12,000 tons of machinery. Both men and machines have been gradually augmented, so that

today it is estimated that some 3,000 factories[1] are in operation, including power plants, paper, cement, textile, steel, oil, sugar and alcohol factories. To insure safety from bombing most of the factories are made of small units, often disguised under thatched roofs so as to make them indistinguishable from the surrounding houses. This is not economical, but we have to wait until the end of the war to make adjustments.

To increase food production, as well as to provide relief for refugees, much has been done to provide irrigation for otherwise wasted land. Most of the irrigation projects are completed or in the process of completion in Shensi, Yunnan, and Szechuen provinces. Altogether there are 258 such projects to provide water for 335,000 acres of land. Also, the substitution of cereal for opium planting is expected to give us an extra crop of 25 million piculs of rice. (One picul is equal to 133⅓ lbs.)

Recent prospecting has given us satisfactory results. Before 1939 nobody suspected that China had oil outside of Manchuria, but this year the oil wells in Kansu Province are expected to yield 5,000,000 gallons of gasoline, 2,500,000 gallons of kerosene and 1,200,000 gallons of crude oil. Likewise, we have discovered tin in Yunnan, manganese in Kweichow, asbestos in Western Szechuen, as well as coal, iron and copper in varying amounts.

A little south of Kiating, the water power from the difference in the levels of the Tatu and Min rivers is being harnessed to provide eventually all the needed electrical power within a radius of 250 miles. For the careful planning and bold execution of China's industrial reconstruction, we are indebted to the National Resources Commission and the Ministry of Economics.

[1] By the end of 1940, there were 1,354 factories, distributed as follows: mechanical shops, 312; mining and metallurgical, 97; electrical, 47; chemical, 361; textile, 282; and others, 259.

Realizing that the universities train leadership, which is the backbone of our resistance, they have never been spared in Japan's wanton destruction.[2] Thus Nankai University, like Louvain, will be remembered in the history of twentieth century vandalism. For the same reason, the Chinese government has been doing everything in its power to preserve these universities by moving faculties, students, libraries and equipment into the far interior at a time when military necessities caused extreme congestion in transportation.

Just before the Japanese invasion, in 1936, we had 108 higher institutions of learning with a total enrollment of 41,609 students. The dislocation due to war reduced the number of colleges and technical and professional schools to 91 in 1937. But in spite of our loss of jurisdiction in enemy occupied territories, the number of institutions increased in 1941 to 132 with a total enrollment of 57,832 students.

Practically seventy-five per cent. of the total enrollment are refugee students; that is, students whose homes are in the occupied territories or whose families have been crippled financially due to the exigencies of war. The first group walked westward for the most part just in front of the enemy's push in 1938, carrying books and bundles under their arms. These have graduated from the institutions and are absorbed in our war and reconstruction projects. Their successors today are the young boys and girls of high school and college age who steal across the enemy's lines from occupied territories and march hundreds of miles on foot, facing hunger, thirst, sickness and uncertainties enroute to freedom and learning.

For these refugee students, the government has to provide for food and lodging as well as for instruction. The

[2] The total loss for educational institutions of all grades from somewhat incomplete returns is Chinese National $252,105,425, or roughly U. S. $72,000,000 at the pre-war rate of exchange.

GIRL STUDENTS BUILD A NEW CAMPUS AFTER BEING BOMBED OUT

pre-war cost for food for each student was about $4.00 a month. Today it is about $200 per month in Chinese currency. Still about twenty per cent. of them need further help to provide for bedding, clothing, books and other educational tools. This has come partially from the Chinese government and partially from American students through the instrumentality of student Christian Associations and United China Relief.

During the war years, there is a distinct increase in the interest of the students in applied sciences as compared with arts. Table I gives data obtained by the Ministry of Education on courses chosen by students before and during the war.

Of the various branches of engineering, civil engineering was most popular at the beginning of the war, but after the Burma Road was closed, mechanical and chemical engineering took its place and will likely continue to be popular as China develops her industries.

While enrollment in the technical courses are steadily on the increase, the rate of increase in the supply of teachers from men returning home after completing their education abroad is reduced because of the cost and difficulty of transportation. This condition is made worse by the fact that many men have been taken from the universities to be put in the factories, at road building and on other projects. We are, therefore,

PERCENTAGE ENROLLMENT IN COURSES

	1936–37	1940–41
Arts	20	11
Law, Political Science & Economics	20	21
Commerce	8	10
Education	8	9
Natural Science	13	12
Engineering	17	21
Medicine	8	8
Agriculture & Forestry	6	7
Others	0	1

A UNIVERSITY SCIENCE LABORATORY DEMOLISHED BY BOMBING

fully aware that we are in great need of well-trained men. The absorption of our graduates into the industries creates a similar dearth of middle school teachers.

The Chinese Society of Engineers is a prosperous and going organization. Its annual meetings have in recent years been held in Chengtu, Kunming, and Lanchow, and each has been attended by over one thousand persons. At such meetings, technical papers are read before its various sections, and general discussions have related to China's program for reconstruction in so far as engineering is concerned. Such meetings have done much to arouse popular interest. The three past presidents of the Society have been Dr. Wong Wen-Hao, for many years head of China's Geological Survey and now Minister of Economics, Mr. Chen Li-Fu, mining engineer and present Minister of Education, and Lin Hung-Hsun, China's leading railroad and highway engineer. Delegates are given travel subsidies or are provided with transportation as a measure of encouragement, partly because travel is very expensive today and partly because engineers are encouraged to visit widely scattered centers of potential industrial importance.

The Science Society of China is an older organization. It was founded by a group of Cornell Students in 1915, including Dr. Hu Shih, Dr. Y. R. Chao and Mr. H. C. Zen. For many years the Science Society also held annual meetings at widely scattered places. The Society publishes *Science*, *Science Graphic* and *Proceedings* of the Society, which in no small degree disseminate scientific knowledge effectively among Chinese youth. Before the war, the Society maintained an excellent printing press in Shanghai and a museum and a research laboratory in biology in Nanking. In the early thirties, branch societies were formed, such as the Chinese Physical Society, the Chinese Mathematical Society, the Chinese Chemical

Society, and several organizations of biologists, each of which maintains one or more publications.

Since most of the members of the Science Society and its branch societies come from the ranks of teachers and workers in research institutions who have been seriously affected by the high cost of living ever since the third year of the war, attendance at its annual meeting is mostly from one geographical region, although papers are contributed by members elsewhere who cannot attend the meetings in person. Last summer the Chinese Physical Society initiated a new type of annual meeting in which meetings were to be held simultaneously in six places. Actually, they were held in four places, Kunming, Chungking, Chengtu and Kweilin. Forty papers were read at its 1941 annual meeting in Kunming. In 1942 there were altogether seventy-two papers. The nature of the papers varied from the practical measurement of the susceptibility of mineral rocks to a theoretical treatment of the thermodynamics of a living cell.

Chinese scientists as a whole have focused their attention on practical problems in order to help in the war effort. The chemist has cracked Tung Oil to give us synthetic gasoline; the biologist and the soil scientist have made thorough study of kinds of soil, the regional distribution and deficiencies to be made up by special fertilizers; the physicist and the electrical engineer have helped in the production and maintenance of electrical communication and power; the geologist has been telling us where to tap for natural resources; and the mathematician has helped in our war efforts by work on ballistics. But still there is strong evidence of interest in pure science. There are men working on the "Omni-Range Electrical Forces and the Static Nuclei," and on the "New Skulls of Mammals of Probably Upper Triassic Age in Yunnan." As another good example, we may take the astronomical expeditions to Lintao, near Lanchow, and to Chunan in Fukien province, not far from the enemy lines, to observe the solar eclipse of September 21, 1941. (The last mentioned expedition failed on account of bad weather.)

Lastly, I must pay tribute to my fellow teachers and research workers in China. Most of them are refugees. They have lost much earthly goods because of bombing, expensive travel, and inflation. They and their families are poorly fed and clothed and have to do much physical labor that a mechanized civilization can never appreciate. But they are joyously training the younger generation and sharing their hardships, and eagerly doing their part to search after truth and to help in the reconstruction of their homeland so that she may become a worthy member in the family of nations.

FRANK JULIAN SPRAGUE, 1857-1934

By Dr. DUGALD C. JACKSON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IT was natural for Frank Julian Sprague to pioneer. The story of his life responds to Walt Whitman's lines:

> All the past we leave behind,
> We debouch upon a newer mightier world, varied world,
> Fresh and strong the world we seize, world of labor and the march,
> Pioneers! O pioneers!

Sprague was a "man o' independent mind."

He was not only a pioneer, but he also was one of the few among the world's population who see in the mind's eye the character and results of proposed revolutionary physical embodiments. Guided by such mind's images, he truly set the patterns of many factors in our present industrial and urban life.

The philosopher William James wrote in one of his essays: "Mankind does nothing save through initiative on the part of inventors, great and small, and imitation by the rest of us—these are the sole factors active in industrial progress. Individuals of genius show the way, and set the patterns, which common people then adopt and follow." Where he used the word "inventors" I understand him to have intended it to be interpreted broadly in all kinds of creative effort. In physical invention Sprague was a genius and his productions and plans have been adopted and followed in world-wide distribution. The sign "no thoroughfare," which is in common acceptance, never cried pause to the iconoclastic mind of Sprague when he was set on producing a through passage; and the world has followed with satisfaction in paths where he led. At the end of a brief outline of his romantic career written in 1934, he himself said of his active life, "The three score years have been those of a ready acceptance of any challenge in electrical engineering progress, a mental elixir which has made life worth living in the effort to add to human progress and comfort, the zest for which advancing years have not entirely abated."

Born on July 25, 1857, at Milford, Connecticut, he was of the ninth American generation from his paternal English forebears. His father was in the business of manufacturing hats. On the death of his mother, in 1866, he and a younger brother fell under the guidance of a maiden aunt who was a school teacher at North Adams, Massachusetts, and there he attended school. In 1874, on the advice of his school superintendent, he entered a competitive examination for a cadetship in the United States Naval Academy. He won the appointment and graduated in 1878, well placed in a class of notable graduates.

Individuals usually are in bondage to the ideas in which they have been immersed since birth, but not so Sprague. He was born with a restless and creative mind. The announcement in 1876 of the invention of the telephone by Alexander Graham Bell, followed by outlines of work in the same field by Gray and Edison, fired his imagination. His interest, however, rested more particularly on the possibilities of electric power. The year previous to his Naval Academy appointment there had been announced those experiments on the reversibility of the Gramme dynamo at the Munich Exposition of 1873 which awakened the world to the possibilities of electric power; and Sprague never lost the sense of impulse with which that announcement fired him.

He was never happy with an uncompleted task. Poetic fervor drove him toward completion. With his course di-

FRANK JULIAN SPRAGUE AT SEVENTY-FIVE YEARS OF AGE.

rected by his highly skilled mind, the excitement of a powerful idea did not divert him onto false trails. Each great creative discoverer or inventor, in proportion to his achievements, to again revert to quotation from the wisdom of William James, approaches the ideal expressed by the words, "The union of the mathematician and the poet, fervor with measure, passion with correctness, this surely is the ideal." Sprague, although without the spirit of the introspective philosopher, exemplified this ideal.

While aboard ship, after his graduation from the Naval Academy, he seems to have given some concern to his chiefs

and his associates by the force of his desires to invent and improve. He had been stirred by the report of the United States Commissioner of Patents in 1849, that contained eloquent words of prophecy regarding applications of electric power which few of the period thought valid, and his spirit of invention was afire.

He had visited the Centennial Exposition of 1876 in Philadelphia while a midshipman at the Naval Academy and been elevated in heart by much that he saw there, as were other youths who later became, like Sprague, well-known in engineering and the engineering industries. To accomplish important ends a man must be polarized so that he tends constantly toward his goal, and visits to the Centennial served that purpose for many young men of ability.

Indeed, the Centennial Exposition was a stimulant in the education of a nation wherein men might independently enterprise, build and produce, to their own benefit, but with due consideration of the welfare of their fellow citizens and their fellow-men throughout the world. Individualism as a clearly defined quality arises only when man recognizes himself as a social animal. In all this Sprague's mind was well directed.

During the two years after graduation from the Academy, he followed the life of a young naval officer, including a period on the Asiatic Squadron at a time when the tragedy and depression of war were not there; but, individualistically, a personal "Midshipman's Notebook" which he kept became filled with memoranda regarding inventions, ranging from telegraphs and telephones to devices for controlling racing of ships' engines. If the clock's ticking off its minutes does not stimulate the lazy, weary or ambitionless man to accomplishment, the rolling years ultimately will overtake him while he is yet empty-handed; but the years had no such reproach for Sprague, for he always maintained himself in fruitful reflection and employment. He depended on thought-directed exertion, and not at all on wishful or indolent thinking. His mind, "like water, willy-nilly flowing," was constantly pushing forward into new and fruitful ideas. Before his life was over, he could well repeat after the poet:

"I have stolen the eggs from the phoenix' nest
And walked by the shores of the Ocean-Sea."

Ordered home in 1880 for examination, he secured a short leave which was dedicated to experiment on an arc-lamp mechanism at Stevens Institute of Technology. But of particular note is the opportunity which he there had to meet Professor Henry Draper (physiologist, chemist and astronomer) and those two pioneer experimenters and inventors in the electrical field, William Wallace and Moses G. Farmer, all widely renowned for their achievements. Sprague's later memories of the meeting with these three men show that shaking their hands and talking with them stirred him mightily. He then was twenty-three years old and already possessed a boiling enthusiasm for invention in the scarceborn field of electrical engineering, of which the problems sparkled before him like stars in the sky of a clear winter night.

Ordered to duty on a training ship for boys, whose tuition as sailors did not much interest him, he planned to install electric lights for the ship using extemporized and borrowed equipment, but his effort at borrowing was unsuccessful. This training ship put in at Newport. There he again met Professor Farmer. He undertook the construction of a novel dynamo and a control switch in the intervals of ship duty.

Naval life in those days was quiet, and he asked for an assignment as assistant to the officer representing the Navy at

the Paris Exhibition of 1881. This request being disallowed, Sprague secured orders for temporary duty aboard a ship being fitted up to become the flag ship of the Mediterranean Squadron, associated with the opportunity of three months leave on arrival at the station. The ship was delayed in sailing (during which time Sprague, incidentally, installed a call-bell system aboard, constructed out of such materials as were available), and when it finally arrived the date was too late for the Paris Exhibition, but he was given the privilege of attending the Crystal Palace Exhibition of London, which was then in progress with great acclaim. A competent engineer without objective duties becomes homesick for action of either mind or muscle. Sprague never permitted himself to suffer from such homesickness. His was a life of vision sauced with discretion.

Arrived at the Crystal Palace, he was made a member of the preferred section of the Jury of Awards and secretary of the section; and thus at twenty-five years of age he became associated with some of the leading scientists of Great Britain. This was (as he expressed it) one of the most colorful phases of his life. In this position he initiated a series of tests of gas engines, dynamos and electric lights. As he extendedly overstayed his leave, he received peremptory orders to rejoin his ship. There he made out an elaborate, well illustrated report which ultimately was published as a United States Naval Professional Paper of 169 pages plus charts and diagrams. This received the commendation of the engineering world in England and America. It was during these tests that features of gas engine indicator diagrams led to operating a sixteen horsepower Otto engine on a forced test with the outside ignition cut off and with only compression firing: that, as he has said, was "a recorded experiment which may be considered the forerunner of the Diesel engine."

Offering his resignation from the Navy, in which he held an ensign's commission, and with a year's leave of absence in his pocket, he made an arrangement to enter the employment of Thomas Edison as an expert assistant. But before returning to America he went to Manchester, England, to test the then newly improved Edison dynamo designed by Edward Hopkinson and to report on the conductor economy derived from using Edison's three-wire system for distribution of electric current. He arrived at home on the celebrated day of the opening of the "Brooklyn Bridge" (May 23, 1883) and was soon sent out to install Edison electric plants.

The poet Horace says of Hebrus (in Conington's paraphrase):

When the deer are flying blindly all the open country o'er
He can aim and he can hit them; he can steal upon the boar
As it crouches in the thicket unaware.

This we can interpret in application to each truly great engineer and inventor. When he puts his hand to a project, however great its difficulty, he successfully carries through. The problem of establishing a process of calculating cross-sections of the copper feeders and mains for Edison three-wire distribution systems, to substitute for the use of diminutive models, was assigned to Sprague. He solved this, and the time required for a lay-out was reduced, says Sprague, from a fortnight "to about four hours." He always correctly ascribed the feeder and main system of constant-voltage distribution to the genius of Edison, but his own arrangement was patented on an application filed on September 19, 1885, and assigned to the Edison Company. Sprague's arrangement comprised the now long-recognized plan of feeders of resistances inversely proportional to the loads they were expected to carry, along

with feeder regulators to compensate for varying conditions of load.

Yet the true engineer absorbed in the fascinating fields of invention is not only interested in his own environment or his own time like a painter, but like a poet is also a prophet. Sprague's eyes were always set beyond the day's work. His intellectual courage and inventive fire brooked no horizon. His brilliant achievements were incubated by mind and thereafter reduced to physical realization for others by means of his experiments. To him the embodiment was realized when the mind painted the picture; and on the picture he would stake his reputation and future. Such qualities require powerful thinking, which is an individual, personal phenomenon and its successful prosecution depends upon the intellectual power and the will of the thinker—qualities that Sprague possessed in high degree. And here we can agree with Rochefoucauld when he says that it is from want of application rather than of means that men fail of success. It was mental application that won for Sprague.

His mind was filled with a vivid picture of the future usefulness of the electric motor, which at that time was yet a feeble infant as far as essential usefulness was concerned. Therefore in 1884 he left his post of employment in the electric-lighting business with Edison and, on a shoe string, started a company of his own called the Sprague Electric Railway and Motor Company. Men lived rapidly in electrical engineering in those days, and Sprague was constantly doing unexpected things. Electrical engineering was not yet called by that name, and few were cultivating the art. Sprague belonged in electrical engineering to the generation of Edison, Weston, Elihu Thomson, Brush, W. Siemens, Mordey, John Hopkinson and a few other great pioneer inventors. To him, engineering invention was a career thrust upon him to absorb his whole soul; but also to be thoroughly enjoyed. His was an enthusiastic, stormy disposition; but he was a tireless worker, both mentally and physically, when his eye was on the ball; and his company was soon making an enviable reputation for the originality, initiative and courage of his work. From his company came, I think, the first electric motors of importance installed in industrial service west of the Missouri River and certainly, for that day, the largest fed from commercial electric currents in the West.

It was in the Autumn of 1884 that the Franklin Institute organized an electrical exhibition in Philadelphia, which was an enterprise of importance for its day. The new company exhibited several of Sprague's inventions and he frequently was a personal attendant at his exhibit where he extolled with emphasis and enthusiasm his self-regulating, constant-speed, direct-current motor, in which the constancy of speed as the load varied was secured by a differential series-winding on the field magnet. It was in this year that the Sprague Electric Railway and Motor Company had been established and Sprague now was fully launched on his great career of invention and promotion in the electric traction and associated fields.

His progress in invention and exploitation took on a tremendous pace. The constant-speed motors rapidly found a place of importance in daily use, although electric power stations and electric distribution circuits were still young and of limited extent in our cities. Our present-day commonplace utilization of electricity in a wide variety of applications was scarcely, if at all, dreamed of. Alexander Graham Bell first publicly exhibited his infant telephone at the Centennial Exhibition in Philadelphia in 1876. Charles Brush in 1878 invented the differential arc lamp, which made street lighting by arc lamps a practicable

enterprise. Edison first publicly exhibited his incandescent lamp in 1880. Sprague's mind in 1884 was planning work for himself, and such planning requires prevision, that is, soundly picturing future practicabilities. To thus foresee the future we must know facts and relationships of the past (Sprague's associations at the Crystal Palace contributed to this) and we must observe the way in which the current of history is caused to swerve by refraction as it flows from the past through the translucent present into the blackness of the future. There is always difficulty in leading the way to a new order of things; but, where willingness is great, the difficulty cannot be insuperable.

In 1887 and 1888 Sprague was providing electric cars for tramway service in St. Joseph, Missouri, and in Wilmington, Delaware; and it was in 1887 that he undertook that hazardous and spectacular contract for constructing an extensive electric railway in Richmond, Virginia, the success of which awakened all city tramway circles in the United States to the serviceability of electric traction on a grand scale in city transportation service. The Richmond road was established in continuous operation on February 3, 1888—fifty-five years ago.

The boldness of the conception and the impetuous courage of the execution which characterized the Richmond effort aroused so much interest that attention was diverted from the brilliancy of the numerous adaptations and inventions which were a part of the enterprise. But the adaptations and inventions were there, and the influence of many of them is still felt in electric traction in all parts of the world where such traction exists. Some of them had been previously embodied in experiments in a short tramway in a sugar refinery and in an equipment for elevated railway service in New York City, in which experiments regenerative electric braking of trains (an important feature in some present day heavy electric traction installations) also had been demonstrated. An old East Indian proverb says, "All oxen can carry heavy loads on a level road. Among them, the stronger ones only can carry such loads on a difficult road," and Sprague again and again proved himself to be one of the "stronger ones." For him, the willingness being great, all difficulties were overcome.

I first met Sprague in 1884 at the Electrical Exhibition in Philadelphia and there was so impressed by his lively vision, enthusiasm and practical wisdom that the glamour never left me. He was eight years older than I, which is a good deal when one is under twenty years of age. But the impression did not fade—indeed, it grew more emphatic in the course of the years as I came to know him intimately as a colleague and friend. It was my privilege in 1911, as President of the American Institute of Electrical Engineers, to confer on Sprague the great Edison Medal which had been awarded to him in 1910 by that Institute, and to express the eulogy on his work which had led up to the award. Said I then in part, which I gladly say of him again:

> "The brave man carves out his own fortune, and every man is the son of his own works," says Cervantes. When Sprague invaded Richmond in 1887, resolutely plunging into a pool of difficulties from which only unceasing fertility of invention and tireless industry could extricate him, he awoke the world of transportation to an acknowledgment that the electric railway, though an infant, had a future. Sprague's restless nature contrasts with the more cautious processes of the able Van Depoele, his rival in the commercial development of electric traction in America; but we forget the financial difficulties of the Richmond experiment in contemplating the brilliancy of the manoeuvre and in rejoicing in the world-wide effect of its success.

Sprague's courage and persistence became proverbial. He encountered heartbreaking difficulties but surmounted

them with success. "Trial is the true test of mortal man," and as Sprague was tested he was not found wanting. With him it seemed that whatever ought to be done can be done. Give to others in Europe and this country all due credit in the development of the electric railway as a useful agent, and we must still admit that Sprague's courageous, persistent, irresistible preaching and practice had a primary influence in bringing about the conditions and producing the inventions which came to afford modern, rapid, clean and cheap electric urban and suburban rapid transit service. So important did this development appear that Sprague's company was absorbed in 1890 by the Edison General Electric Company, which is one of the two major components which were later merged to compose the great company known as the General Electric Company.

In 1892 Sprague formed a partnership for carrying on independent inventions, but shortly thereafter he formed the Sprague Electric Elevator Company and went into the construction of electric elevators, which he delighted to look upon as vertical transportation devices —which, of course, they are. This grew into an important business before it was absorbed by other companies.

Having formulated his vision of electric elevator service, he went with dash into the business of building and installing elevators controlled by electric master-controllers such as now are commonplace where high speed elevators are needed in tall buildings. Besides introducing automatic control for elevators this led to another important invention in electric traction. Laying, in his mind, several master-controlled electric elevators in a line on the level, he invented the "multiple-unit" control for electric trains; and he introduced the invention into commercial service by means demanding a courage that commands admiration from even the deepest doubter of the business wisdom of the spectacular process. I have heard Sprague speak modestly of the multiple-unit invention as no more than a simple arrangement of devices; and, in fact it is that, but simplicity in apparatus is a natural offspring of brilliancy in conception. The multiple-unit control conferred many advantages for rapid-transit train service—among others the possibility of utilizing the weight of the total train load for traction adhesion and thereby increasing the acceleration in starting, thus increasing average speed between stops, all associated with notable flexibility in the make-up of trains.

After its first application to motor-car trains on an elevated railway in Chicago, where the substitution of multiple-unit electric trains in place of steam-locomotive-drawn trains was completed in the spring of 1898 (forty-five years ago) the multiple-unit control made its impress so deeply on urban and suburban rapid transit that multiple-unit electric trains and urban rapid-transit electric transportation are substantially synonymous terms. It is of world-wide use, and it has now gone even a step farther and is used for the control of railroad locomotives with electric drive, in situations where two or more locomotive units are coupled together to get power to draw a heavy train.

It is not necessary for me to point further to the undeniable importance of the multiple-unit control. It has made rapid transit by subways in great cities a practical mode of transportation; has greatly improved the character of elevated railway and suburban train service; and has contributed to convenience in handling fast heavy trains in heavy railroad service. By these characteristics it has unobtrusively contributed to the comfort of the average dweller in the great cities. Convenience and safety are powerful forces of social cohesion. Along with this we must remember that

the production, transformation (which requires power) and distribution (which includes transportation) of animal, vegetable and mineral goods, in addition to transportation of persons, make the chain which contributes to human material welfare and comfort in living.

A great change has come over the world in twenty-five hundred years. For example, we would find it beyond comprehension that Philadelphia and New York or Boston should go into war against one another, as was characteristic of the individual cities of Classical Greece. This difference has not sprung solely from political betterment. The intimacies in the relation of culture and commerce resulting from convenient and rapid transportation, electrical communication, and the influence of productive industry make such city inter-warfare incredible to us, and wars now usually cover great areas when they occur,—areas in which the populations differ contrastingly in ideals and languages. A common language associated with the Roman alphabet is now a priceless heritage of three hundred million people of the world, including ourselves. The world needs more of such mutuality for its welfare now that great inventors have been doing such influential work in drawing nations together in their physical relations.

It seems that an engineer who creates new industries or profoundly influences old ones, needs to possess some of the same kind of courageous initiative that moved Martin Luther, Erasmus or Wesley. Something of this may be seen in the Crystal Palace tests of 1882, the Richmond electric railway work of 1887 and the conception of the multiple-unit control. It is manifest that Sprague's life was infected with the spirit of enquiry and the joy of accomplishment; and joy in useful accomplishments is essential to the realization of civilized living. Sprague cared as little for ease of body or mind, when adventure in invention was available, as a toothless man cares for a diet of nuts when porridge is available. He earned well the title often given him of "Father of Electric Traction."

"Champagne doth not a luncheon make nor caviare a meal;" and inventions of primary order usually must be fortified with many lesser but important supplementary novel features. As a consequence, Sprague's total contribution of inventions, in all types, to the electrical industries was large in number. He also achieved various inventions which were of primary character but were not as important as his motor and traction contributions. Satisfaction with existing knowledge and practice is the principal deterrent to the pursuit of additional knowledge such as Sprague followed.

One of these lesser inventions produced in 1926 was the plan of two electric elevator cars in the same shaft (such as one intended for express service and one for local service) with automatic limit switches arranged to prevent collisions between the cars. Another was in the field of railroad train control, as an external automatic safety device, which strongly animated his mind when the Interstate Commerce Commission was pressing the railroads to make trial installations. However, conditions changed sufficiently so that these independent devices did not seem necessary in railroad service and Sprague's activity in the development was temporarily laid aside. Other inventions were in the field of electric signs, and he invented an alternating current, induction smelting furnace in the nineties, but the then inadequate supplies of alternating current led him to drop the project; and so on.

Sprague was not a traditional inventor without individual control over his course, like a twig in a mill race, but he

held his mind rigorously to responsibility for conceptions useful to the humankind. And his was a belief that an intense regard for the very best accomplishment available in an individual is the touchstone for maintaining (as well as establishing) a good reputation. When it became necessary to relinquish steam locomotive hauling through the tunnels entering New York City for the trains of the New York Central Railroad, Sprague seized the opportunity and proposed to demonstrate hauling the trains by electric locomotives. This proposal was not accepted, but a Committee for Electrification was established under the chairmanship of W. J. Wilgus who was Vice President and Chief Engineer of the railroad, with Sprague and three other men competent in railroad practices as members. Plans and standards were promptly worked out, and in 1905 the project went into operation with a success that still continues, using multiple-unit operation for suburban trains and electric locomotives for drawing through trains when within the limits of the electric zone.

With all of his activity as an inventor and expounder of engineering projects, Sprague was still a good citizen who had his eye on the public welfare. In 1911, when problems arose relating to plans for additional passenger subways in New York City, Sprague became alarmed at the apparent lack of consideration for coordination of the underground transportation system for the city, and he prepared an elaborate explanation of the needs, which was presented at a special public meeting called under the authority of the American Institute of Electrical Engineers. This exposition clearly had influence on the plans which finally were adopted and put in effect.

Then with America's entry into World War I, and his nomination by the American Institute of Electrical Engineers and the Inventors' Guild to membership in the United States Naval Consulting Board, Sprague entered into its affairs with his usual enthusiasm. He was chairman of an important committee of the Board, but directed his special attention to the development of depth charges for destroying enemy submarines and the development of delayed action fuses for armor-piercing projectiles. In the days of distress from the success of enemy submarines that almost isolated Great Britain from America and caused a deep food shortage in Britain, he was actuated by the doctrine that the way to strangle the submarine threat was to render the shipping lanes between the two countries so dangerous to the marauder that attacks would not be dared. As a matter of fact the submarine menace was substantially eradicated by that process, and the fighting forces and the people of Great Britain, France and Belgium received the needed munitions, equipment and food.

Unless the present U-boat menace arising from the fermented consciences of Hitlerism and the Japanese is successfully met by application of the same doctrine but over a wider range of sealanes, we may come to the pass where Americans have no choice but to assume belief in what they are told to believe. We Americans may, however, rest in the expectation that present-day men of the stamp of Sprague and his confreres will be equally successful if we loyally support the utmost war efforts laid down by the military and scientific leaders.

Sprague was twice married. First to Mary Keatinge of New Orleans in 1885, with whom he had one child—a son named Frank D'Esmonde (in later years known as Desmond). They made their home in New York, where Sprague's work was primarily centered. The second marriage was to Harriet C. Jones of New Hartford, Connecticut, in 1899. Here there were three children, Robert C., Julian K. and Frances A. They

gradually came to regard Sharon, Connecticut, as their home, where Sprague (as he grew older) more and more delighted in his rose garden in summer, although they maintained a residence in New York City. A creative inventor of great mental activity is said to be a man who is hard to live with in ease of spirit, and the wife who lives an unclouded life with such a one needs to possess the qualities of love and devotion in high degree. Sprague was most fortunate in his home relations.

On July 25, 1932, the seventy-fifth anniversary of his birth, a meeting was held in the Auditorium of the Engineering Societies Building in New York City at which the principal speaker was Dr. John H. Finley, who expressed an exalted view of the importance to the world's welfare of such engineers as Sprague. This reminds us that Alexander Hamilton said in the *Federalist,* "I believe it may be regarded as a position warranted by the history of mankind, that, in the usual progress of things, the necessities of a nation in every stage of its existence will be found at least equal to its resources." As progress involves the development of wants which are of a higher order, we may paraphrase Hamilton's apothegm by submitting that every nation is likely to find useful every facility and expenditure that can be secured by the utmost draft on its resources through lofty invention.

There was presented to Sprague at this anniversary meeting a tribute consisting of six beautifully bound volumes of letters and photographs from four hundred and eighty-two associates and friends, many of whom were men notable for their distinguished standing in engineering, education and art.

He was a member in many engineering societies. He received many honors and medals from societies and universities. He received the Gold Medal of the Paris Exhibition of 1889 for his development of electric railways, the Elliott Cresson Medal of the Franklin Institute in 1904 for his multiple-unit train control, the Grand Prize of the Saint Louis Exhibition in 1904 for his development of electric railways, the Franklin Medal of the Franklin Institute in 1910 for fundamental inventions and achievements in electrical engineering, the John Fritz Medal of the Founder Engineering Societies in 1934 (and conferred posthumously in 1935) for distinguished service as inventor and engineer through the application and control of electric power in transportation systems; all in addition to the distinguished Edison Medal previously referred to.

He was an honorary Doctor of Engineering of Stevens Institute of Technology, honorary Doctor of Science of Columbia University, and honorary Doctor of Laws of the University of Pennsylvania, besides being an honorary member in various engineering societies. The American Institute of Electrical Engineers delighted particularly to honor him, as of it he was a past president, an Edison medalist and an honorary member. A bronze bust of him is cherished in its quarters. The Franklin Institute also delighted to honor him, as he was twice its medalist and was an honorary member. He was a past president of the American Institute of Consulting Engineers as he had been a distinguished consultant in electric railway and electric elevator matters for several manufacturers of electrical machinery and for certain railroads. Creative success is founded on faith and character, and these qualities in Sprague were fully appreciated by his associates.

He died from the effects of pneumonia on October 25, 1934, and was buried with naval honors in the National Cemetery at Arlington. On October 27, the Herald-Tribune of New York as part of a fine tribute said, "Not merely as father

of the trolley, but of all transportation by electricity, his name is firm."

An epitome of Sprague's spirit is contained in the last paragraph of a letter which he wrote to me at a date succeeding his seventy-fifth birthday celebration:

"What a lot we have seen, and what a joy it has been to have lived in, and helped make, this electric age. I do not believe that any future half century will see such a widespread development affecting the march of civilization in so many diverse ways. So I am glad that I have been present at the laying of the corner stone, and helped carry up some of the bricks." To this we may add that, in this age of science, the religious sense of the brotherhood of men is deeper and more favorably controlling than in any of the preceding ages of the world, and that is one of the effects of replacing the wand of the magician or medicine man by the slide rule, the blue print and the test tube. If we could make, as Aristotle said long ago, the shuttle "weave and the plectrum touch the lyre without a hand to guide them, chief workmen would not want servants, nor masters slaves." It is not so much the effects of science and invention that ruin the world (as is often charged by wishful thinkers) as it is the vain culture that gets so refined that it can no longer tolerate or enjoy folk tunes like "Arkansas Traveler," "Billy in the Low Ground," "Fire in the Mountains," "Leather Britches," "Money Musk," "Pop Goes the Weasel," "Turkey in the Straw" and their relatives.

Genius is innate, a matter of birth, and presumably the consequence of some combination of the genes at conception. It may or may not command world prominence, at least in its own time, but Sprague, in his single life, made engineering history and (in a fullness that few have the privilege of achieving) he added to the material comforts needed to support civilized living. As with some of the other founders of electrical engineering, it is difficult to see where Sprague secured his incentive to invention in the power applications of electricity. There was substantially no immediate heritage or environment to suggest a cause. His father was superintendent of a hat factory and his paternal forebears for generations were of conventional occupations like landowner or farmer. Of maternal ancestors we know little. Sprague's own mother apparently was devoted to her children, but she died while Sprague was young and he fell under the care and direction of a maiden, school-teacher aunt, who apparently was rather reserved. As the spirit for adventure in invention was apparently in Sprague before he went to the Naval Academy, it seems to have been an inheritance since there appears insufficient cause in his youthful environment to originate such a spirit. We are thus left without clues as from whence came the genes which in combination produced his genius, but we know that he lived with an urge to make inventions that would be useful to the human kind.

"One star differeth from another star in glory" the Apostle said, referring to tangible appearance. We use his words, but apply them to imponderable human characteristics of the individuals. Frank Julian Sprague was a star of magnitude. If all the world would permanently embrace peace and live with industry and thrift, while encouraging creative inventors to show the way to convenience and comfort, we soon would enjoy a wealth, health and happiness near to the millennium.

HISTORY OF THE MEASUREMENT OF HEAT

I. THERMOMETRY AND CALORIMETRY

By Dr. CARL B. BOYER

DEPARTMENT OF MATHEMATICS, BROOKLYN COLLEGE

THE years 1942 and 1943 mark important anniversaries in the history of thermal quantitative methodology. They celebrate the 350th year since the invention of the thermometer (c. 1592) and the 200th year of the scale of Celsius (1742). They commemorate the death of the inventor (Galileo, † 1642), and the birth and death of two who improved the instrument (Newton, b. 1642 O.S., 1643 N.S.; Halley, † 1742). These years also mark precisely a century since Mayer (1842), Joule (1843), and Colding (1843) established the principle of the conservation of energy, the greatest generalization which thermometry has made possible. The present time may therefore be regarded as peculiarly fitting for a review of the basic steps in the development of quantitative thermotics.

The importance of thermal phenomena had been remarked as early as the Hellenic period. Heat and cold were recognized by Democritus and Heraclitus as playing a vital part in the dynamic world of nature, and these qualities were intimately bound up with the Empedoclean theory of the four elements and with the Hippocratean humoral pathology. The classical expression given to such doctrines about a century later by Aristotle and his school continued to dominate scientific thought for close to two thousand years. Peripatetic science, however, remained essentially *qualitative* and failed to see the possibility of, or at least the tremendous importance of, a means of determining the extent to which the properties hot and cold were present in any given situation.

Hellenistic science stands in marked contrast, in its attention to *quantitative* studies in astronomy and mechanics, both to the earlier Hellenic period and to the later Greco-Roman age. However, no basis for the measurement of thermal phenomena was found at that time. Heat could not be seen or weighed, and the physiological sensation was far too unreliable to serve as a measure. It is scarcely surprising, then, that the determination of specific heats came about two thousand years after the earliest measurements of specific gravity, and that the inverse proportionality of these for gases was discovered another hundred years later. Nevertheless, a bold attempt in the direction of a quantitative study of heat was made in medicine by Galen through a classification of drugs and simples on the basis of a scale of four orders or degrees of heat and cold. Such an arrangement was bound to be highly subjective and dogmatically a priori, but it served to inspire further efforts toward a quantitative basis. In particular, the Galenic views were continued and elaborated upon by Arabic commentators, so that in the work of Alkindi (c. 850) one finds adumbrations of an important distinction—that between intensity and quantity of heat and cold.

The decline of Arabic learning happily coincided, at least roughly, with the rise of a more vigorous scientific interest in the Latin world. The natural science of Aristotle was eagerly discussed by the Scholastic philosophers and, especially at Paris and Oxford during the four-

teenth century, by them was given a significantly new quantitative orientation. This tendency was most pronounced in two fields upon which the mathematical mind of Archimedes had failed to touch—dynamics and thermotics. In the former branch the late medieval period introduced two important concepts—that of impetus or inertia and that of acceleration, both uniform and non-uniform. That the age was somewhat less successful with respect to the study of heat may perhaps have been due to the fact that it studied the dynamic aspects of heat without first having mastered thermostatics. Richard Suiseth and others discussed changes in thermal intensity and content in much the same terms as they had linear velocities and accelerations; and Nicole Oresme represented such variables graphically. During the fifteenth and sixteenth centuries these discussions were continued. Giovanni Marliani and his contemporaries and successors adopted a scale of eight degrees of calidity and frigidity, and on this basis sought to distinguish between the temperature of an object and the quantity of heat which it contained. However, speculation and logical deduction here remained relatively fruitless because no sound body of raw data had yet been gathered through precise quantitative observation. It is interesting to note in this connection that although during the medieval period it was suggested that heat might be a form of motion, anticipating Francis Bacon and others by some three hundred years, such an adumbration of the modern view could not take on appropriate significance without the empirical mensurational work which during the seventeenth and eighteenth centuries followed upon the invention of the thermometer.

The earliest forms of the thermometer appear to have been suggested by the sixteenth-century revival of interest in the classical mechanical works of antiquity, rather than through Scholastic philosophical discussion. The technological tendencies of the Greek world had been overshadowed to a great extent by the speculative tradition which medieval thought had sedulously fostered. Consequently the works of Archytas of Tarentum, of Philo of Byzantium, of Ctesibus and Hero of Alexandria survive now only in the form of fragments preserved largely through Latin translations of Arabic versions of the Greek originals. And yet the mechanical experiments of these men played a significant role in directing the advance of early modern science, especially with respect to thermal measurement.

In a *Treatise on Pneumatics* of the third century B.C. Philo described an intriguing experiment which was destined to have far-reaching implications. A large hollow glass globe was sealed hermetically to one end of a long glass tube, the other end of which dipped into an open flask filled with water. Philo found that when the apparatus was placed in the sun, some of the air within the globe was forced out through the water in the flask. On being placed in the shade, water flowed from the flask back along the glass tube and even into the sphere of air. This simple demonstration of the expansive property of air was repeated with numerous ingenious modifications by Hero, who cites Philo in this connection.

Although Philo's discovery became the basis of various clever automatic devices, it appears never in antiquity to have been tied up with philosophical discussions on the qualities hot and cold. This apparatus of some twenty-two hundred years ago is in all essentials a thermoscope, but such an appropriate interpretation apparently occurred to no one in ancient or medieval times.

During the later sixteenth and early seventeenth centuries Hero's works became well-known. Della Porta was in-

terested in Hero's *Pneumatica* chiefly as furnishing examples of "natural magic." Consequently in 1589 he described the experiments of Philo and Hero as illustrating the changing density of air; the idea of this as a measure of the degree of heat did not occur to him. To Galileo, however, such an interpretation did occur soon after he was established at Padua in 1592, just about three hundred and fifty years ago. Using Philo's arrangement, Galileo fastened a straight thin glass tube to a hollow glass ball about the size of a hen's egg. This he then held vertically with the open end of the tube in a flask of water. As the glass ball was warmed by the hand, air was driven out of the tube and bubbled up through the water. When the hand was removed, water rose in the tube as the enclosed air cooled and contracted. The level to which the water rose in the tube Galileo recognized as a rough indication of the extent to which the air had been heated. Galileo was thus the first one to give a means of determining temperatures independently of the highly equivocal sensation of touch. His device is to be regarded as the earliest crude thermometer, the first objective means of describing thermal phenomena quantitatively. However, inasmuch as in this early form it lacked a definite scale and was subject to changes in atmospheric pressure, Galileo's instrument frequently is referred to as a baro-thermoscope.

Galileo seems not to have appreciated his invention of the thermometer, his reference to it being quite casual. Consequently credit has sometimes gone to rival claimants, although it appears to be clear from Galileo's correspondence that he is definitely entitled to priority in this invention, the description of which has been supplied by his associates. During the eighteenth century the invention customarily was ascribed to Drebbel in 1608; but Drebbel's position was precisely that of Porta—he repeated the observations of Philo and Hero, but seems not at first to have used the instrument as a heat-measurer. Serious pretensions have been advanced also on behalf of the Paduan physician, Sanctorius, who in about 1612 described thermometers in connection with commentaries on the works of Galen and Avicenna. Sanctorius, however, never claimed the invention for himself, and it is possible that he learned of the instrument through his colleague Galileo. Independent invention has sometimes been ascribed also to Salomon de Caus in 1615, to Fra Paolo Sarpi in 1617, or to Robert Fludd even later, but such ascriptions lack adequate confirmation.*

Whereas the use of the telescope spread rapidly after its invention in 1608, application of the thermometer was by contrast surprisingly slow. This situation is probably to be explained by the fact that the former instrument was applied in *qualitative* description, whereas the latter was intended for *quantitative* determinations. Quantitative analysis is more difficult than qualitative, although it is also generally more valuable. To make the thermometer an effective measure of heat intensity a precise and objectively reproducible scale was necessary; but throughout the seventeenth

* While this paper was in proof, there appeared a valuable review of the claims of Galileo, Sanctorius, Fludd, and Drebbel by Dr. F. Sherwood Taylor in "The origin of the thermometer," *Annals of Science,* V (1942), 129–156. Sherwood closes his excellent analysis with the following paragraph:

"To sum up the whole position, it seems not improbable that Santorio, Galileo, Fludd and Drebbel each invented the thermometer independently. Galileo seems, at some period between 1592 and 1603, to have been the first inventor, while Santorio in 1611 gives the first written record of the invention, published or unpublished. Drebbel may have invented the two-bulbed thermometer at any date between 1598 and 1622. Fludd may have modified Philo's apparatus into the weather-glass, but did not do so until some period between 1617 and 1626."

century no such standard was adopted. Many of the early scales—including those of Telioux in 1611, of Mersenne in 1644, of Morin in 1661, and of Fabri in 1669—were divided into eight spaces, following the late medieval philosophical tradition. Sometimes these intervals were further subdivided into eight or sixty parts each—the latter in accordance with the Babylonian astronomical tradition. Astronomy and geometry undoubtedly led Galileo's friend Sagredo in 1615 to divide the interval between the greatest heat of summer and the extreme cold of winter into 360 parts or "degrees." The famous thermometers of the Florentine Accademia del Cimento were variously divided into fifty or one or more hundred parts. Otto von Guericke adopted a scale of seven degrees and Fludd one of fourteen. Renaldini and Newton used scales of twelve parts.

As there was no uniformity during the seventeenth century with respect to scale divisions, so also no general agreement was reached as to desirable fixed points for determining the limits of the scale. Winter and summer heat, the temperature of a deep cellar, the melting point of butter or of anise-seed oil, the freezing and boiling points of water were among those proposed; but not one of these secured general approval.

During the century the form of the thermometer had changed considerably. Jean Rey in 1632 described a thermometer for fever patients in which a rise of temperature was indicated by the expansion of water in a flask up into a long thin neck. This liquid thermometer was followed by others, including the alcohol and mercury instruments of the Florentine Academy. The change from air to a liquid as the thermometric substance reduced the discrepancies due to atmospheric pressure, but did not wholly eliminate them. At some time before 1654, however, Ferdinand II and the Academicians sealed their thermometers and removed this source of error. Greater accuracy was now attainable, provided some standard method of calibration could be adopted. Boyle, Hooke, and Huygens in 1665 suggested that a *single* fixed point, such as the freezing or boiling point of water, be chosen as a starting point, and that temperatures above and below this be measured by the proportionate expansions and contractions of the thermometric substance. Adoption of this principle would have made thermometers universally comparable, but agreement could not at that time be reached. Shortly afterwards it was suggested by Fabri, Dalencé, Renaldini, Newton, Halley, Roemer, and others that *two* fixed points would be preferable, the interval between these to be subdivided in some manner to be agreed upon. On the basis of these principles,—using either one fixed point or two—the thermometric scales which we now use—Fahrenheit, Centigrade (or Celsius), Réaumur, and Absolute—were established during the first half of the eighteenth century.

The origin of the Fahrenheit scale is to be found in the work of Roemer. The Danish astronomer in calibrating thermometers set his zero at the lowest temperature he could obtain with a mixture of ice and salt; his upper point was the boiling point of water. On dividing the interval between these extremes into sixty parts, Roemer found that the freezing point of water fell at about 7½ or 8 and the temperature of the body at 22½. Fahrenheit in 1708 visited Roemer in Copenhagen and subsequently undertook the calibration of thermometers along similar lines. As a maker of meteorological instruments—the thermometer was indeed at that time often referred to as a "weather-glass"—Fahrenheit was concerned primarily with the lower portion of Roemer's scale. He therefore retained Roemer's zero, but as his upper fixed

point he adopted normal body temperature. Moreover, he found Roemer's 22½ divisions between these points inadequate for precision, so that he multiplied the number by four. Subsequently he found it convenient to change from 90 to 96 the number of degrees in this range. With these modifications, as the result of which the freezing and boiling points of water incidentally fell at 32 and 212 respectively, the present Fahrenheit scale was established.

The origin of the Centigrade thermometer is not so clearly indicated. A scale of a hundred parts had appeared among those adopted by the Florentine Academy, and other centesimal thermometers were used in the first half of the eighteenth century by La Hire and Du Crest, but these were not associated with both the freezing and boiling points of water. On the other hand, Renaldini in 1694 had proposed these latter fixed points, but he subdivided the interval duodecimally. A suggestion that Renaldini's fiducial points be associated with a centesimal scale is contained in a letter of the great naturalist Linnaeus, but this is undated and so leaves unanswered the question of priority. Apparently the first thermometer constructed along those lines was that described in 1742 by Celsius. In this the freezing point was chosen as 100 and the boiling point as 0, but a few years later the scale was inverted by his colleagues to establish the present Centigrade scale.

In the period between the work of Fahrenheit and that of Celsius there arose a third scale which also achieved wide popularity. In 1730–1731 Réaumur proposed a thermometer established on the principle of Boyle, Hooke, and Huygens. Starting from only one fixed point, the freezing point of water, he chose his divisions on the basis of the volumetric expansion of the thermometric substance —one degree for each increase by 1/1000 of the original volume of alcohol. On this scale water was found to boil at 80°. However, because of the varying quality of thermometric spirits, this boiling point subsequently was adopted as an arbitrary and invariable second fixed point, thus standardizing the scale for so-called Réaumur thermometers.

Interest on the part of both Fahrenheit and Réaumur had been influenced by the earlier works of Amontons, to whom is due the idea of an absolute scale of temperature. Amontons had been led to thermometry through meteorology and the problem of varying atmospheric pressure, but in emphasis he departed from the traditional view. The air thermometer had been the first to be developed, but it had soon given way to sealed liquid thermometers. Liquids, unfortunately, have not only very small rates of thermal expansion, but these rates are unequal for different substances and are not uniform for any one fluid over different temperature ranges. The same is true also of solids, the unequal expansions of which were used in 1747 by Musschenbrock to construct a new type of thermometer or pyrometer. About 1701, on the other hand, Amontons had discovered that the thermal expansion of air is surprisingly uniform. He found that if a fixed volume of air at any initial pressure is heated from a moderate temperature to the boiling point of water, the pressure will in every case be increased by about one third. From this fact he inferred that for equal increments or decrements in heat or temperature the pressure of a gas will be increased or decreased by the same fraction of the pressure at some arbitrary point. He therefore suggested a scale based on one fixed point—the boiling point of water—with degrees of heat intensity to be measured in terms of the proportionate increase or decrease in the pressure of a given volume of air at this initial temperature. Thus Amontons found that a pressure of 73 units at the boiling point corre-

sponded to one of 58 units at greatest summer heat and to one between 51 and 52 units at the freezing point. He then made the significant observation that by extrapolation below this point one could infer that at the zero temperature of this scale the air would exert no pressure; it would have no elasticity because its parts would then be contiguous and cease to move. He suggested that this might well be regarded as an absolute zero of heat content or intensity. However, scientists at the time were skeptical of his conclusions, and this suggestion of an absolute thermometric scale remained largely unnoticed. Late in the century and early in the next Amontons' observation on air was rediscovered and generalized for other gases by Lambert (1779), Charles (1787), Volta (1793), Gay Lussac (1801), and Dalton (1802). Toward the middle of the nineteenth century this work on gases was associated by Kelvin and Clausius with independent developments in thermodynamics which also pointed to the same absolute zero, and hence temperatures measured from this point (by means of the adjusted Centigrade system) often are referred to as degrees Kelvin or Absolute.

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The establishment in the early eighteenth century of adequate thermometric scales gave precision to the idea of heat *intensity*. The problem of heat *quantity*, on the other hand, had received no satisfactory consideration. The recognition of the constancy of fixed points, on which thermometry is based, preceded by about a century the determination of heat capacities upon which calorimetry depends. Arabic and Scholastic philosophers were aware that thermal effects are determined by both intensity and quantity of heat and cold. The latter factor, they knew, was to some extent dependent upon the quantity or mass of the hot and cold bodies. They accepted this functional relationship as a simple proportionality. Renaldini, Fahrenheit, Boerhaave, and others did indeed establish experimentally that, when unequal quantities of the *same* substance at different temperatures are mixed, the rise or fall in temperature is very nearly proportional to the masses involved and to the difference in temperature. In the case of two *unlike* substances, however, this rule failed to hold. Mercury, for example, had far less thermal effect at a given temperature than did an equal mass of water. In fact Fahrenheit, following a suggestion of Boerhaave, had found on mixing equal *volumes* of these two substances at different temperatures that, although the density of mercury was more than thirteen times that of water, the thermal effect of water was in every case greater by about three to two. This experiment might well have led these men to make a systematic quantitative study of the heat capacities of various substances. On the contrary, Boerhaave looked upon the result as confirming roughly his conjecture that heat tends to be distributed uniformly throughout all space, regardless of the substance occupying any portion of this space. He held that observed discrepancies in thermal density or capacity were due to inaccuracies resulting from the fact that heat quits and is acquired by bodies at varying rates. In fact, attention at the time seems to have been drawn away from the idea of heat capacity by a strong interest in speeds of thermal communication, such as Newton's law of cooling. Richmann in 1753 noticed that mercury gives up its heat very rapidly, and that substances in general have characteristically different rates of cooling; but he failed to distinguish clearly between temperature and thermal capacity.

The view of Boerhaave precluded any such concept as that of specific heat, but it pointed toward the possibility of a direct measurement of the amount of heat in a given region of space. The idea

of materiality had been impressed with such thoroughness on the eighteenth century that Boerhaave was led to attempt to weigh heat, for gravity is one of the chief properties of matter. Moreover, the fact that metals increase in weight during calcination tended to confirm the suspicion that heat was a gravitating substance. The results of Boerhaave's experiments, however, were distinctly negative, and he was forced to conclude that heat was a material *sui generis* having no weight. Musschenbroek and Buffon questioned this conclusion, and the latter insisted that he could indeed associate an increase in weight with a rise in temperature. However, Black, Rumford, and others were not convinced by Buffon's results, and heat remained throughout the century among the imponderables.

The *absolute* quantity of heat could not be determined by the balance, but successful attacks upon the problem of *relative* quantities of heat were nevertheless made independently by a number of men, with credit for priority apparently going to Black. He arrived at his results shortly before 1760, although they were not published during his lifetime. The result of Fahrenheit and Boerhaave on mixing water and mercury impressed Black as having a significance which, surprisingly, these men had overlooked. Rather than indicating roughly the uniform distribution of heat in space, Black saw that the experiment showed clearly that different substances have characteristically different capacities for heat. The capacity of mercury, for example, he found to be less by about 30% than that of an equal volume of water. Experimental determination of the capacities of substances relative to that of water were made also at somewhat the same time by Deluc, Wilcke, Irvine, Crawford, Lambert, Watt, and others. Such values, when equal masses are compared, have since become known as specific heats. This work inaugurated what may be regarded as a second great branch of quantitative thermotics. It is a surprising fact that thermometry, or the determination of heat intensities, had developed for more than a century and a half before the effective rise of calorimetry, or the measurement of relative thermal content or capacity. This is difficult to explain inasmuch as no new instrument was necessary in the latter case. A balance and a thermometer suffice to measure the relative heating effects. The method of mixtures long before had been used by Renaldini in connection with quantities of a single substance at different temperatures to determine the degrees on a thermometric scale. Calorimetry would follow as a simple corollary on mixing quantities of two different substances at unequal temperatures. Yet this was not systematically developed until it had been bound up by Black and others with the interesting phenomena of change of state and the discovery of latent heats.

Experience had shown that the temperatures at which substances undergo a change of state are more or less fixed and constant. On the other hand it was apparent that a given quantity of a substance did not freeze or boil away instantaneously on being lowered or raised to or beyond the freezing or boiling point. The very appreciable lag in this connection was interpreted as due to the fact that air, through which the transfer of heat is generally made, is almost 800 times less dense than water and hence absorbs or gives up very slowly the heat necessary for equalization of temperature. No appreciable increase in the total heat content of a body was judged necessary to melt ice or to boil water, so long as the temperature was maintained at or above the freezing or boiling point. Such serious misconceptions show that satisfactory quantitative studies often are of greater significance in the advance of

science than are general theories as to the nature of things. Such at least was true of the science of heat in Black's day.

Black in 1757 had found reason to question the traditional view with respect to change of state. He saw that if no great change in heat content were necessary to bring about a change of state, then it would be truly remarkable that ice melts so slowly in warm surroundings. Great quantities of snow and ice on thawing should rather be expected, through sudden liquefaction, to produce irresistible torrents and inundations. Black concluded that, contemporary opinion notwithstanding, a great *increase in the quantity* of heat must be brought about to give melting ice its fluidity, even though this is not accompanied by any *rise in temperature*. The added heat was merely "rendered latent." Moreover, for any one substance and change of state, this latent heat was a perfectly definite quantity directly proportional to the mass involved. In view of this, Black thought of the melting process as a sort of chemical reaction: a mass of ice at 32° when combined with 139 degrees [Fahrenheit] of heat yields an equal mass of water at this same temperature. His figure for the latent heat of fusion thus differed but slightly from the modern value. For the latent heat of vaporization, however, Black arrived at "not less than 774 degrees [Fahrenheit]," which is smaller by almost 20 per cent. than that accepted at the present time.

Black utilized his discovery and determination of latent heats as an alternative method of determining relative quantities of heat or of thermal capacities. If a hot body is placed in a cavity in a block of ice which is then covered with a slab of ice, the quantity of heat lost by the body in cooling to the freezing point of water will be directly proportional to the mass of ice which is melted. So convenient was this method of determining heat quantities, when used in connection with improved ice calorimeters, that the amount of heat required to melt a unit weight of ice in many cases was taken as the unit of heat, replaced now by the calorie and British thermal unit.

The calorimetric researches carried out by Black and others fortunately were not subject to qualifications which might follow from a particular theory as to the nature of heat. This work answered only the question "How much," not "How" or "Why" in some mechanistic sense which might "explain" the phenomena of heat by appealing to analogies with other more immediate and familiar experiences. Black himself was never a lover of theory and so seems to have felt a definite reluctance to adopt any specific doctrine in this respect. By that time the Aristotelian view of heat and cold as primary and unanalyzable qualities had been abandoned. In the seventeenth century Bacon, Descartes, Boyle, Hooke, Huygens, Hobbes, Locke, and Newton had reiterated the medieval suggestion that the essence of heat was in some way to be found in motion. In spite of the rapid rise of dynamics, such a doctrine at the time remained sterile because the relationship between heat and the ordinary phenomena of motion could not be expressed in quantitative form. Atomists, such as Gassendi, rejected the dynamic theory and advanced instead the view that heat was not a quality but a substance, a subtle fluid the particles of which insinuated themselves into the interstices of matter. Cold was by some likewise regarded as a substance, until in 1790 Prévost's theory of exchanges replaced the doctrine of frigorific rays. Boerhaave, Musschenbroek, and Buffon meanwhile had sought in vain to establish the material view of heat quantitatively through the balance, but their failure did not alter the relative plausibilities of the substantial or

materialistic and the dynamic or mechanical theories of heat. Adherents of the former had the ready answer, suggested by optical, gravitational, magnetic, and electrical phenomena, that heat was an imponderable substance. Moreover, Newtonian influence favored a view which could be expressed in terms of attractive and repulsive forces between particles. Boerhaave's fluid theory therefore dominated thought for over a century. When in 1738 the Académie des Sciences offered a prize for an essay on the nature of heat, the three winners (Euler, Voltaire, and the Marquise du Châtelet) all postulated the substantial theory. This view of heat adequately satisfied the craving for an interpretation which could be visualized in terms of sensory experience. Moreover, it was flexible enough to allow of modifications *ad hoc* to explain such phenomena as elasticity, change of state, modes of communication, thermal expansion, heat capacity, heat of compression, latent heat, and solar radiation. It was generally assumed that the caloric particles were in constant motion, that they repelled each other, and that they were attracted to the atoms of a substance with a force which varied with the heat capacity of the material. During compression, or on rubbing substances, some of the caloric of the body was squeezed out, thus causing the body to become sensibly hot. Conversely, the intrusion of more heat into a body resulted in a greater internal repulsion among the caloric particles and hence resulted in an expansion of the substance. A change of state could be brought about by injecting heat in such amount that the attractive bonds of the atoms of the substance were overcome by the repulsive forces of the caloric particles for each other. The additional heat necessary to overcome these atomic forces was not free but was in some way bound up with the substance; *i.e.*, it was latent and produced no sensible increase in the temperature of the substance. The idea that heat was material was rendered plausible also by the confusion between ordinary sensible heat and radiant energy. Solar radiation was regarded simply as a steady stream of caloric particles, a view which in its simplicity contrasted markedly with the need on the part of dynamic theories of heat and light for a supposititious all-pervading medium or ether possessing quite extraordinary properties. In view of such a ready adaptability to all situations, it is small wonder that the substantial doctrine of heat persisted up to the middle of the nineteenth century. Fortunately, however, quantitative experimental work in thermotics meanwhile was hampered little, if at all, by notions as to the ultimate nature of heat. Indeed, a certain indifference toward such speculations was evinced not only by Black but also by Laplace and Lavoisier who continued his calorimetric researches.

In the *Mémoires* of the Académie des Sciences for 1780 Laplace and Lavoisier published a paper on heat which contained points of view of great significance. During a review of the respective advantages of the dynamic and materialistic theories of heat, the authors pointed out that in either case the conservation of free heat in the mixing of bodies was admitted by physicists. This paralleled the conservation of mass which Black and Lavoisier had demonstrated in chemical reactions. Then Laplace and Lavoisier indicated that if heat were motion, it should be measurable in terms of $[1/2]mv^2$, or kinetic energy. This observation might have stimulated investigations leading directly to the laws of thermodynamics. Unfortunately the authors of the article seem to have been unaware of the possibilities lying in this direction, for they dropped the idea and went on to a consideration of heat as a material substance. The thermal fluid

was enthroned among the chemical elements as Lavoisier's "caloric," and many years later Laplace in his *Mécanique céleste* continued to support the material theory.

Laplace and Lavoisier failed to forge the quantitative link between heat and motion, but they did make significant contributions in the quantitative correlation of the chemical and biological aspects of thermal phenomena. The phlogiston theory had made thermal phenomena so completely a part of chemistry that the latter subject was known as the science of heat and mixture. Lavoisier was directly responsible for the overthrow of phlogiston through the substitution of the oxygen theory of combustion and respiration, but he retained a "chemical" view of heat. This view may, incidentally, account for the myopia with respect to a quantified mechanical theory. The caloric doctrine appealed more strongly to men who were keenly aware of the need for quantitative statements. It was natural, then, that an attempt should be made to measure the amount of caloric which is evolved during the chemical process of combustion. Laplace and Lavoisier burned charcoal in their improved ice calorimeter and determined that in this oxidation the production of one ounce of fixed air (carbon dioxide) from food and pure air (oxygen) was accompanied by heat sufficient to melt 26.692 ounces of ice. Inasmuch as there was at the time no concept of energy or, *a fortiori,* of chemical energy, Lavoisier believed that during combustion some of the heat which had been combined with the oxygen principle in the pure air was liberated as sensible heat.

Ever since the days of classical Greek medicine the lungs had been regarded as playing a thermostatic role in tempering the vital heat of the blood. However, Lavoisier held that the function of respiration is to supply to the lungs the newly discovered element oxygen which there combines chemically with the products of digestion to maintain the heat of the body. To show that this oxidation is entirely comparable to the ordinary visible process of combustion, Laplace and Lavoisier sought to determine calorimetrically the quantity of heat generated in animals during the formation of carbon dioxide. Because their method failed to take into account the oxidation of hydrogen, the result was too high—about 13.7 ounces of ice for 224 grains of fixed air—but it was sufficiently close to the expected result to indicate that respiration is a combustion during which the heat lost by the body is renewed through the conversion of oxygen to carbon dioxide. Animal heat was shown to be not perceptibly different from caloric. This was a vindication of that faith in the unity of nature which had been expressed boldly by Buffon and which later inspired the discovery of the conservation of energy. Moreover, it made possible for the first time an understanding of that color contrast between arterial and venous blood which sixty years later directed Mayer to this very law which Laplace and Lavoisier so narrowly missed.

The collaboration of Lavoisier and Laplace on the specific heats of gases had failed to yield satisfactory results, yet such efforts also led directly toward Mayer's work. The basic law of *thermometry* for air (and for other gases) had been established by Amontons at the beginning of the eighteenth century, but the *calorimetry* of gases was undeveloped a hundred years later. The elasticity and low specific gravities of gases delayed the determination of their specific heats long after they were isolated and identified. French scientists of the first half of the nineteenth century devoted much attention to this problem before arriving at a satisfactory solution. After Gay-Lussac in 1802 had rediscov-

ered and generalized the law of Amontons, he turned his attention to the thermal capacities of gases. Ten years later he still lacked accurate values for their specific heats, but he had made the important discovery that the heat capacities of equal volumes of air, hydrogen, oxygen, and nitrogen were nearly equal. The following year Delaroche and Bérard verified this fact through the first reasonably accurate direct measurement of the specific heats of gases at constant pressure. The determination of specific heats at constant volume nevertheless still presented difficulties. In 1816 interest and attention to this problem were heightened by a bold conjecture on the part of Laplace. For well over a century no one had been able to explain why the velocity of sound as *calculated* by Newton from the elasticity of the air should be smaller by about 1/6 than the *observed* speed. Laplace finally hit upon the correct explanation: the vibrations constituting sound waves are so rapid that the compressions and rarefactions are not isothermal, as Newton had supposed, but adiabatic. On the basis of such vibrations Laplace was able to show that Newton's calculated velocity of 997 feet per second is corrected on multiplying it by $\sqrt{\gamma}$, where γ is the ratio of the specific heat of air at constant volume to the specific heat at constant pressure. Laplace estimated γ as 3/2, but the known velocity of sound showed that γ should be about 1.4. This latter figure was confirmed somewhat later by the values of γ and of the specific heats of diatomic gases obtained by Clément and Désormes, Gay-Lussac, Dulong, Regnault, and others. Such data, through the kinetic theory of gases, confirmed the discovery of Dulong and Petit in 1819 that heat capacities are directly associated with atomic theory. Moreover, during the second quarter of the century this work was destined, through the establishment of the law of the conservation of energy, to play a central role in the rise of the theory of thermodynamics, which was the third stage in the development of quantitative thermotics.

MALARIA: MALADY OF THE MARSHES

By Dr. BLAKE DANIELS PRESCOTT

THE NEURO-PSYCHIATRIC INSTITUTE OF THE HARTFORD RETREAT, HARTFORD, CONNECTICUT

SUPERSTITIONS as to the origin of a disease often serve to indicate the frequency of its occurrence. For where one's speculation is, there one's concern is also. Consider the case of malaria. Still among man's serious ills, it has given rise to a wide array of highly fanciful views.

It has been thought, for instance, that febrific poisons arising from fissures in the earth's surfaces were responsible for the malady. There was the belief, too, that milk exposed to the night air would entangle epidemic swamp poisons—that gases from decaying vegetation, or ethereal oils from living plants, might produce the disease. Some people were even reluctant to gather swamp grapes, because the exuded juice might trap the "noxious effluvia" of the marshes. Even the heavenly bodies came in for a share of suspicion. The sailor viewed with special alarm an eclipse, or a moon that was full. Tides, climates, and seasons also, were blamed at times for febrile epidemics otherwise unexplainable.

But, if there have been new additions to the catalog of popular theories in

even fairly recent times, accounts of malaria itself date back to the earliest days of recorded medicine. In Biblical times mosquitoes infested the valley of the River Jordan and the Dead Sea, consequently some of the fever illnesses referred to by the scriptural writers very likely are malarial. There is the account, for example, in Leviticus 26 : 16 in which the author speaks of "the burning ague." In Deuteronomy 28 : 22 the writer mentions fever and "an extreme burning." Still another passage, Matthew 8 : 14, records Jesus' visit to Peter's home where his wife's mother lay sick with fever. Further, a reference in Luke 4 : 38 relates that the mother of Simon's wife fell ill with "a great fever." Fever is again mentioned in John 4 : 52, and in Acts 28 : 8 Publius' father is described as suffering from both fever and dysentery. These ancient accounts do not, of course, constitute in themselves an accurate basis for a diagnosis of malaria. However, there is the further consideration that early Palestine was so situated as to make the presence of malarial epidemics highly probable.

In the days of ancient Greece the population of Athens and the surrounding country experienced repeatedly the calamitous consequences of malaria. Mosquito breeding grounds were abundant in the numerous swamps about Athens, and the site of the famous stadium was once a marsh. The unhappy effect of such conditions upon the inhabitants was vividly represented in Aristophanes' reference to the "shivers and fevers which by night strangled your fathers." Similarly, the physician Protagoras speaks of intermittent fevers terminating fatally—probably the pernicious variety of malaria. It is known, too, that there was speculation as to the role marshlands played in producing fevers, and that the Italian Varro (B.C. 116–27?) suspected that inhalation of swamp organisms caused disease. Opinions like these were held in other localities as well, since excavations have revealed that drainage was practiced in Greece, Crete, and elsewhere. Records indicate that Rome was believed more healthful than the rest of the Italian peninsula because of its elevation, and since its valleys were drained by the Cloaca Maxima. Even so, fevers were prevalent enough for Cicero (B.C. 106–43), and later Livy (B.C. 59–A.D. 17), to select "pestilencia" as descriptive of conditions in the outlying districts of the imperial city. Finally, malaria swept over both countries with uncontrolled violence, very probably contributing to the decline of Grecian culture, and to the subsequent fall of the Roman empire.

As to just what sufferings were visited upon the peoples of the Old World, we have no exact way of knowing. However, accounts do suggest that both benign and malignant malaria continued to reign with murderous fury. Then, by the time of the seventh century, we are again provided with specific evidence as to the prevalence of the disease for Bede, in England, refers to malaria in his *Historia Eccleciastica Gentis Anglorum*. Not long afterward, during the ninth century, we find the Persian Rhazes, who was credited with being the first eminent physician to write in Arabian, asserting that the spleens of those who drank marsh water became enlarged and hard. Somewhat later, Avicenna, writing around 1000 A.D., clearly revealed a familiarity with quartan fevers. It is interesting to note, too, the recognition which this Mohammedan philosopher accorded to the therapeutic possibilities of benign malaria, for in his Canon of Medicine he states: "One disease becomes the medicament for curing another."

As to whether, during all this time, malaria was prevalent in the western world we must depend upon conjecture

—though the impression is that it was widespread among the Indians of South America, especially the Incas of Peru. We do know, however, with the coming of the era of exploration, that malarial-like fevers materially interfered with the colonizing enterprises of the European adventurer. There is the account, in this respect, that Columbus was seized with "terrible fevers" in January, 1494, while in Hispaniola. Also, malaria was prevalent in that country following the introduction of Negro slaves in 1501. In contrast, the early Spanish settlement in Florida in 1566 was less affected than were the English colonists who later attempted to settle Jamestown. It was from this time on, however, that malarial fevers assumed an increasingly important role in New World history.

Meanwhile, back in the Old World men were still endeavoring to understand the true nature of an old problem along with their interest in a New World. Epidemics like that of 1557–58 in England wrought deadly havoc and wrecked many enterprises. Yet, such tragic ravages in England, as well as those on the Continent, stimulated a more thorough study of fevers. Such was the contribution in 1624 of the Belgian physician Spigelius. His four books on *Semitertiania* provided a lengthy treatise on intermittent fevers, and a good description of the paroxysms. Later, in 1692, the celebrated London practitioner, Richard Morton, made his distinguished contribution entitled *Pyretology*. Then Francis Torti, a Modena professor, in 1712 published a classical work on pernicious fevers, and other contributions were to follow, lending further inspiration to the relatively new spirit of research.

Although at this late date in the history of the disease advances were being recorded as to the nature of fevers, creditable efforts had been made very much earlier. Even as far back as 500 B.C. Hippocrates, moved by the "shivers and fevers" of his countrymen, had endeavored to discover more exactly the nature of their ailments. As a result of his study of fevers he felt they should be classified as "the continual, some of which hold during the night and have a remission during the day; semi-tertians, tertians, quartans, quintans, septans, and nonans." Of these types he considered the quartans least dangerous, and he contended that they "carried off other great diseases." Some time later, around 180 B.C., Plautius, too, wrote of fevers, as did Celsus in 50 A.D. Then a century passed, and Galen ventured the opinion that all the quotidian fevers resulted from phlegm, that yellow bile induced the tertian, and black bile, the quartan attacks. Quartan fevers, he concluded, were effective in "carrying off" attacks of epilepsy.

Although this knowledge of fevers resulted from studies made over many centuries, contributions as to treatment were more immediately productive once cinchona had been discovered. Some of our earliest information goes back to about 1620 when a Jesuit missionary at Chucuifaca, Peru, learned from the natives that a miraculous bark could heal those suffering from malarial fevers. Later accounts romantically tell of the Countess, wife of the viceroy of Peru, falling ill in 1638 with a fever from which her physician, Juan de Vega, could not deliver her. A Spaniard, possibly the governor of Loxa, advised her physician to use the bark of the tree which contained the secret febrifuge. At first hesitant, she finally resolved to follow his advice and recovered "as if by enchantment." A year later she and her physician sent some of the powdered bark to Spain. Ten years afterwards the Jesuits of Rome introduced it commercially in Italy as "Jesuit's or Cardinal's Powder," and in Spain as "Countess' Powder." In 1677 the cinchona bark

appeared in the London Pharmacopoeia as "Crown Bark," and the red bark was included ten years later. We know that cinchona at first was a costly article, and that de Vega sold it in Italy for nearly one hundred dollars a pound.

A new era in malarial therapy followed the introduction of cinchona, and researches as to its application were soon forthcoming. Barba, a Spanish physician, was first to write of its merits in 1642 at Seville. By 1651 physicians in Rome fixed the dose of the powder at two drams, recommending the use of laxatives beforehand. Not long after that the British physician, Sydenham, decided to prescribe cinchona just after the first attack to lessen, or prevent, a second paroxysm. Soon Sebastian Badio, impressed with the superiority of the medicine, published a dissertation in 1663. In 1679 the Englishman Talbor introduced his method of treatment in France and successfully treated the dauphin. Subsequently, Louis XIV purchased his secret remedy for 80,000 livres and an annuity of 2000 crowns. Later, when the king himself was seized, he recovered with the powder administered in wine. Up to this time the specificity of cinchona for malaria had been disregarded, but now fevers could be separated into those which the bark cured, and those which remained unaffected by it.

Comparable to the progress which had been made in the treatment of the disease was the advance made in the classification and cultivation of the trees. LaCondamine contributed one of the early studies in 1738, the results of which he published in the memoirs of the Academy of Sciences. His descriptive report enabled Linnaeus to trace the characteristics of the genus, which he named cinchona in memory of the Countess of Cinchon. Soon botanists discovered other species, the more outstanding investigators being Mutis, Ruiz, and Pavon.

Following these discoveries, another advance was made when, in 1820, the French pharmacists, Pelletier and Couventou, isolated quinine from the bark. Pelletier read their paper on "Chemical Researches on Cinchonas" that same year before the Academy. These workers proposed the name "cinchonine" for the gray and yellow bark, and "quinine" for the red bark. Some years must still pass, however, before the beneficial effects of quinine could be completely realized for, as Sir Richard Burton soon wrote:

> How short this Life, how long withal;
> how false its weal, how true its woes,
> This fever-fit with paroxysms to mark,
> its opening and its close.

There now came a time when cinchona plantations became necessary so as to supplement the nearly depleted South American supply. As early as 1792 Ruiz advanced the idea of cultivating trees outside their native regions. Still it was not until 1848 that Weddell brought seeds from South America to France, and strenuously argued in favor of plantations. His seeds were planted in the Jardin des Plantes, Paris, and by 1850 the young plants were shipped to Algeria. Two years later seedlings were sent to Java where the Dutch made the first important attempt to cultivate the trees. Soon the British government sent Clements Markham on a Peruvian expedition to obtain seeds for southern India and the island of Ceylon. Through these and other early efforts an adequate supply of quinine of high quality soon became assured.

Although by the middle of the nineteenth century an improved understanding of malarial fevers and their treatment had resulted, the nature of the causative organism still remained unknown. Rasori, however, had recently advanced the idea that intermittent fevers were caused by parasites, and that the paroxysms resulted from their peri-

odic reproduction. From a somewhat less scientific standpoint Burton, in 1856, wrote in his *First Footsteps in East Africa* that the natives of Somaliland thought mosquito bites caused fevers. He explained this belief as a superstition which resulted from fevers and mosquitoes being present at the same time. Livingstone, a year later, mentioned in *Missionary Travels* that fever sometimes follows insect bites. Again, in 1865, he wrote in his *Narrative of the Expedition to the Zambesi* that mosquitoes indicated the presence of malaria. More scientifically, Klebs and Tomassi-Crudeli, in 1879, found what they thought was the cause of the disease. They had discovered a bacillus in the Roman marshes which, when injected into animals, produced a fever similar to malaria. They proposed the name *B. malariae* for this organism, and it remained the accepted pathogenic agent until 1880 when the French army officer, Laveran, made his epochal discovery of malarial parasites in the human blood. Five years afterward Golgi demonstrated the tertian and quartan life cycles, at which time Marchiafava and Celli made related studies. Then, in 1895, Ronald Ross in India made the observation that the parasites developed in the mosquito, a finding which was predicted by Manson a year earlier.

By the close of the century, then, malarial fevers were well understood, the drug quinine had become the recognized specific for the disease, and the plasmodium had recently been identified. Progress had also been made as far as drainage of swamps and screening of dwellings were concerned, which favorably affected the incidence in some areas. However, despite these distinct advances in the understanding and control of the disease, malaria has continued to constitute a serious medical problem. Not only has it remained among the afflictions of civilian populations, most especially in the tropics, but it has presented a formidable problem among the armed forces in time of war.

Not the least enemy to be reckoned with in the Spanish-American War was the anopheline mosquito. So, too, malaria was one of the diseases which made the building of the Panama Canal almost as much a problem of medicine as of engineering. In this respect, James Stanley Gilbert's "Panama Patchwork" recalls its frequent consequences:

> Close the door—across the river
>   He has gone.
> With an abscess on his liver
>   He has gone.
> Many years of rainy seasons
> And malaria's countless treasons
> Are among the many reasons
>   Why he's gone.

Still more recently, with the opening of the eastern front during World War I, the malady reached epidemic proportions—the British forces alone reporting over 300,000 cases in the course of three years of hostilities.

What toll this age-old affliction may take during the current global conflict no one can safely predict. Yet, with the tropical regions once more constituting major theaters of war, it is clear that malaria is, and will be, a further enemy affecting military plans. Especially is this true now that the Dutch East Indies, normally the source of ninety per cent. of the world's supply of quinine, are enemy possessions. Fortunately, certain synthetic substitutes are available, such as atabrine, now officially recognized under the nonproprietary name of quinacrine.

STATUS AND PROSPECTS OF CLIMATOLOGY

By Dr. C. W. THORNTHWAITE and Dr. JOHN LEIGHLY

SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

Introduction

Meteorology consisted originally of knowledge of all phenomena of the middle space between the earth and the heavenly spheres but came in time to mean knowledge of the atmosphere alone. As meteorology took definite form as a science in the nineteenth century its content became still further restricted. For nearly a century the primary concern of the meteorologists has been the phenomena comprised in the term "weather"; that is, irregular short-time fluctuations in the state of the atmosphere. So close is this identification of meteorology with knowledge of weather that the science is often regarded as merely a technique whereby the irregular changes of weather can be predicted.

Through its exclusive association with weather, meteorology has lost an important part of its former content. This lost content has to do with the regularly recurrent or periodic changes in the physical state of the atmosphere, from day to night and from summer to winter. The seasonal rise of temperature in spring is a climatic phenomenon, recurring every year; its average rate, and the temperature to be expected at any particular date, are elements of the local climate. The conditions of the atmosphere expected at any place on the basis of experience constitute its climate. It is climate, therefore, that has been lost from view as it assumed its present state. Meteorology has ceased to concern itself greatly with the knowledge of climate; it has, in fact, tended to become merely "weatherology," although climatology is still claimed as one of its constituent parts.

While the public has been given an ever more elaborate weather service, the scientists and administrators who are responsible for the long-time trends of public policy have not had the climatologic counsel they might have found useful. Agriculture, for example, has long been the object of solicitous attention on the part of Federal and State agencies. These agencies have encountered climatologic questions at many points and at frequent intervals, just because they have so often directed their activities toward changing the routines followed by farmers. That such matters as the introduction of new crops, the control of harmful insects and plant diseases, the introduction of farming practices for the prevention of erosion, and the resettlement of drought-stricken farmers have a close dependence on climate is well known to the specialists who work with them.

Nevertheless, the climatic aspects of these problems are handled vaguely and their critical relations remain to a large extent undefined. There has been no group of specialists in climatology that might have provided both example and counsel for the treatment of the climatic factors in problems of such general concern.

Climatology in the United States

A century ago meteorology was mainly climatology. Weather records were analyzed by the well-established methods of astronomy. The daily and annual march of various weather elements were seen to be related to the astronomic motions of the earth, and it was believed that behind the irregular fluctuations there was regularity of recurrence com-

parable to the regularity of the motions of the planets. Accordingly, the essence of climatology was thought to be averages or normals, and numerical expressions for regular recurrence. Joseph Henry, in 1855, stated that the irregular weather fluctuations could be identified and studied in terms of the regularity of climate.

> We . . . need not, in this branch of knowledge, . . . be confined to the mere discovery of the existence, and the measure of the constants of nature, but, uniting the results of observations with those of experiments in the laboratory, and mathematical deductions from astronomical and other data, we are enabled, not only to refer the periodic changes to established laws, but also to trace to their source, various perturbing influences which produce the variations from the mean, and thus arrive, at least, at an approximate explanation of the meteorological phenomena which are constantly presented to us.[1]

Before his time others had already discovered that the arithmetic treatment of meteorologic observations did not lead to results as satisfactory as were obtained from astronomic observations. "On the one hand," wrote a Swedish scientist in 1824, "is the most regular order to be found in Nature; on the other, to the best of our present knowledge at least, the most confused variability, so that we see no way in which any common periodicity may be found."[2]

A distinct change from the methods of astronomy came with the introduction of the synoptic view of weather, which takes account of conditions occurring simultaneously over a large area. Almost as soon as weather observations began to be available for a large number of places in eastern United States the study of individual storms commenced, and information on their size, form, and rate and direction of travel began to accumulate.

[1] Joseph Henry, "Meteorology in its Connection with Agriculture." In Report of the Commissioner of Patents for the year 1855, p. 358. Washington [D. C.] (34th Cong., 1st Sess., H. Ex. Doc. 12.)

[2] Frih. Ehrenheim, "Om climaternes rörlighet" (Stockholm, 1824: 206).

The invention of the telegraph made it possible to bring together quickly weather observations made simultaneously at a number of places and to determine the position and characteristics of individual storms on successive days. During the 1870's, when the possibilities of this procedure became evident, public demand for weather forecasting led most countries to establish official meteorologic services. In the United States they began on November 1, 1870,[3] under the control of the Signal Service of the Army. This move made of meteorology an official technology, if not an "official science," as it has sometimes been called. The attention of meteorologists was shifted; whereas in the 1820's the object of investigation by the science of meteorology was "climate," by the 1870's it had become "weather."

Even though the public meteorologic service of the United States remained in the War Department for two decades, it established during that time several special services for the benefit of agriculture, prominent among which was a system of frost warnings. In 1891 the Service was at length transferred to the Department of Agriculture, under the name "Weather Bureau."

In both institutional and individual study of the atmosphere, the importance of climatology to agriculture was recognized throughout the nineteenth century. Lorin Blodget's admirable *Climatology of the United States . . .*, published in Philadelphia in 1857, contained chapters on the relation of native and cultivated plants to climate, and the bulk of the book deals with climatic limitations to the agricultural development of the

[3] The best account of the development of meteorology in the United States until the early nineties of the last century is contained in a series of papers issued as Report of the International Meteorological Congress, held at Chicago, Ill., August 21–24, 1893, under the auspices of the Congress Auxiliary of the World's Columbian Exposition, *U. S. Dept. Agr., Weather Bureau, Bull. No. 11, Part II*, 1895, pp. 207–335.

western half of the United States, which was then awaiting settlement. The meteorologic organization within the Signal Service also contributed to public knowledge of the climate of the new western lands, through the preparation of a number of reports of which the following are illustrations: "Rainfall of the Pacific Slope and the Western States and Territories," 1888; "Climate of Oregon and Washington Territory," 1889; "Climate of Nebraska, Particularly in Reference to the Temperature and Rainfall and their Influence upon the Agricultural Interests of the State," 1890; and, after the transfer of the Service to the Department of Agriculture, "Certain Climatic Features of the Two Dakotas," 1893.

These publications were a part of the scientific stocktaking of the new lands of the West, comparable to the contemporary work of the Geological Survey. Together they made a profound impression on American natural science. More intensive investigation of the relations between climate and agriculture is reflected in "Tables of Rainfall and Temperature Compared with Crop Production" (Signal Service Professional Paper 10) 1882, and in some of the early bulletins of the Weather Bureau, among which are to be found: E. W. Hilgard, "A Report on the Relations of Soil to Climate" (W. B. Bul. 3), 1892; Milton Whitney, "Some Physical Properties of Soils in their Relation to Moisture and Crop Distribution" (W. B. Bul. 4), 1892; P. H. Mell, "Report on the Climatology of the Cotton Plant" (W. B. Bul. 8), 1893; and Cleveland Abbe, "A First Report on the Relations between Climates and Crops" (W. B. Bul. 36), 1905, which was actually written in 1891. Although these reports are also very general, they suggest lines for further research.

A large fraction of the total effort put forth by the Weather Bureau is now, as always, expended on the collection, compilation and publication of climatologic observations. This work is absolutely essential. It is, however, an extremely laborious task that is easily put aside. Concerning this the first chief of the Weather Bureau once said:

> The number of observations involved is so enormous, the necessity for accuracy so increases the amount of work, and after the compilation the reduction of the results into a lucid form, capable of easy reference, is itself so slow a process, and such work seems so suitable to be displaced by other work more urgent but less important, that progress is very slow.[4]

It is easy to understand why little energy remains for the analysis and interpretation of these data and especially for the study of special climatic problems.

At its inception the Weather Bureau was charged with "the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States." In carrying out this responsibility it was necessary to introduce rigid standardization of its instruments and of the manner in which they are exposed. The Weather Bureau has had, moreover, to keep the number of cooperative climatologic stations within manageable limits. The net of cooperative stations is close-meshed enough over most of the country to permit the drawing of good general maps of the climatic elements, but it is not and can not be dense enough to reveal the local differences within the larger frame of climatic contrasts that are important to growing plants. These local climatic relations slip readily through the meshes of the existing net of climatologic stations.

Microclimatology

A standardized system of climatologic observations, although the only kind that can be used for the general purpose of establishing and recording the climatic conditions of an area as large as the

[4] Mark W. Harrington, "What Meteorology is Doing for the Farmer." In Yearbook of the U. S. Department of Agriculture, 1894, p. 119, Washington [D. C.], 1895.

United States, can not be expected to provide answers to climatologic questions that arise in relation to the production of the many kinds of crops and the other varied agricultural activities in so large an area. For one thing, the climatic elements that affect different crops in different parts of the country are not the same. For another, the standardized observations for the purposes of synoptic meteorology or for general climatologic purposes seek to avoid the local influences of vegetation and soil as completely as possible, whereas, what is required for agricultural and biological purposes are observations near the ground in the zone where the plants actually live.

The climate of a region as determined by means of the standardized observations is more or less of an abstraction. Actually the region is a composite of innumerable local climates; the climate of the ravine, of the south facing slope, of the hill top, of the meadow, of the cornfield, of the woods, of the bare rocky ledge. These local climates may vary greatly among themselves. For example, the climates of adjacent north- and south-facing slopes may resemble in many respects the standard climates of places hundreds of miles away to the north and south.

Furthermore, the climate five feet above the ground in a standard weather shelter is very different from that within a few inches of the ground in the open. Nocturnal temperatures are lower and daytime temperatures are higher near the ground than a few feet above it. For example, the range in mean monthly minimum temperature is as great within five feet of the ground vertically as in a belt 300 miles wide from north to south at the standard level. Diurnal variations in moisture concentration are much greater within an inch of the ground than at the height where the standard observations are made. Wind velocity increases with height; when it is nearly calm near the ground the wind may be quite strong five feet above.

The climates of areas of very limited extent are called microclimates. They are clearly the ones that concern the farmer, the agronomist, and the biologist. The standardized climatologic stations are neither situated nor equipped to measure temperature or humidity at the places and at the times that are critical for crop plants. It may be confidently stated that few problems that involve relations between living organisms and climate can be solved without special procedures in observation and in the treatment of observational data. When light on such problems is sought in the observational data as they are published, it is generally sought in vain.

The standard observations do not, as has been supposed, give an average of climatic conditions over a considerable area. They are in themselves microclimatic observations, and may differ appreciably from representative conditions, depending on the nature of the microclimate in which they are taken. The temperature regime in a standard shelter at standard height above the ground gives no measure of the range of temperature conditions at different heights over a considerable area.

The general climatology of the United States and the pattern of climates over the earth have been pretty well understood for a long time. Good maps of the climatic elements have been prepared and considerable progress has been made in the classification of climates. It is certainly worth while to refine and revise the climatic maps and to improve the classifications.

The most important present task, however, is in the field of microclimatology. For the biologist it is more important to know the pattern of climatic distribution between the ground and the tree tops or the pattern over a field or a farm than it is to know the world pattern. The facts of microclimatology are subject to

systematic generalization just as are those of general climatology; it is the responsibility of the climatologist to obtain these facts and to make the generalizations.

Rough correlations are actually found between the published standard climatologic observations on the one hand and the behavior of organisms of economic importance on the other. That such correlations are found at all signifies that in the particular relations studied the available climatic data run more or less parallel to the values of the climatic elements that are critical. For example, the summer precipitation collected in a standard raingage may be roughly proportional to the soil water accessible to the root hairs of crop plants growing in the immediate vicinity. The maximum and minimum of temperature recorded within an instrument shelter on successive days probably march approximately parallel to the temperature inside the husks of an ear of corn. Only if an investigator is lucky, will the proportionality or parallelism be close enough to be of use.

For nearly two centuries investigators have been seeking for relationships between plant development and various factors of climate and many times it has been shown that available climatologic observations can not be expected to yield satisfactory results. One of the clearest statements of this viewpoint was made by Köppen in 1871, in an investigation of heat and plant development. He said:

> I believe that this last consideration serves to destroy the beautiful illusion that it is possible to represent the development of plants, even those of a single species, by means of a general formula which contains temperature, light, humidity and other external agents as factors. But, to be sure, whoever finds illusion more pleasant than sober knowledge is not disturbed by such considerations; so he goes on his way in peace and it is no fault of his if others can not follow him.[5]

[5] Wladimir Köppen, "Waerme und Pflanzenwachsthum," *Bull. de la Société Impériale des Naturalistes de Moscou*, Vol. 43, 1871, p. 110.

There are innumerable current examples of failure to solve important agricultural and biological problems because of the inadequacy of existing knowledge concerning local climates. Here are only a few.

An entomologist has been searching for the climatic elements that may control the distribution and spread of the European corn borer. If the climatic range of the insect could be identified, a costly quarantine might be relaxed, and much public money saved. This entomologist has proved that climate and weather are the principal variable factors responsible for the distribution and spread of the insect. However, he has failed to find any relations, that can serve practical ends, between the behavior of the insect and any of the standard climatologic observations that are available.

A cereal chemist is studying the protein content of wheat in connection with an important problem in human nutrition. He has found that protein concentration varies from county to county, and from year to year at the same place, and has evidence that differences in climate and weather are responsible for these variations. The detailed climatologic observations that are necessary to determine the climatic controls have not been made.

An agronomist wished to determine the influence of climate on the variation of yields of several crops over a period of years on fields having a single soil type. The climatological data available included only maximum and minimum daily temperature and daily precipitation. It became clear that these observations made according to standard procedure at one place in an area of over 200 square miles had little connection with the life processes in the multitude of individual plants comprising the crop.

An agronomist finds that alfalfa seed develops well in some districts but not

in others that have the same kind of soil. He believes that these differences are due to local differences in climate, but he is unable to determine what they are.

A forester is faced with a high mortality among seedling trees in an important afforestation project. He was unaware of the fact that the climate near the ground is very different and much more severe than is indicated by temperature observations made within a shelter at standard height.

The solution of such special problems obviously requires a program of observation designed for the express purpose of tracking down the critical climatic factors and measuring them at the particular place and time where and when they are effective. Plants and animals live by maintaining an equilibrium in the exchange of matter and energy with their environments. The matter and energy involved in their direct climatic relations consist primarily of water and heat. A little too much or too little in an essential organ at a particular time—that is all that may be needed to destroy the plant or animal. It is not to be expected that the standard exposure of standard instruments should yield more than an exceedingly rough indication of the values of the climatic elements at the points in space and the moments in time where and when they count most in the life of organisms.

Damage from frost is one of the most direct and simple relationships that exist between a climatic element and a plant. The adverse effect on the plant is due not to a lack of sufficient energy to permit normal development but rather to a definite destruction of plant tissue. In its frost-warning services in fruit-growing areas, the Weather Bureau has set up special systems of instrumentation that depart widely from the standardized type. This service is an outstanding example of what can be accomplished by developing special observations for special purposes.[6] If special instrumental installations are required for study of the relatively simple effect of frost on plant development, they are all the more necessary in the investigation of the more obscure influences, such as the effect of high temperature or drought on crop yield.

Each problem requires study from the climatic as well as from the biologic side. Special exposure of instruments, sometimes the construction of special instruments, always the special handling of observational data are required. Each organism has its own rhythm that is at least in part independent of the calendar. Observational data must be grouped according to the phases of the life cycle of the organism. The most useful method of organizing climatic data can be found only through study of that life cycle. The task is not one for the biologist alone nor for the climatologist alone, but for both in collaboration.

To that collaboration the biologist can bring his previous knowledge of the organism and his techniques for obtaining more knowledge about it. The climatologist can bring his knowledge of how temperature and humidity vary within distances that are small in relation to ordinary meteorologic observation, but significant to a plant or an insect; of how instruments may be installed, and if necessary devised and constructed, so as to give the observational data needed; and of how these data may be handled so as to yield the maximum of insight. In order to be most useful in a collaborative study the climatologist must obtain more information than is now available on the climate of the layer of the atmosphere next to the ground; he must know

[6] Nearly forty years ago a microclimatic study on "Frost and Temperature Conditions in the Cranberry Marshes of Wisconsin" was made by Henry J. Cox, of the Weather Bureau. This was a magnificent pioneer effort along new lines, and it is a great misfortune that it was not followed up with many other similar studies.

how temperature, moisture, and wind vary with height above the ground, within the cover of vegetation and immediately above it, and he must be able to say how the vertical gradients of temperature, moisture, and wind vary through the day and from season to season.

It is scarcely necessary to remark that a mutually satisfactory job of collaboration inevitably leads to the discovery of more jobs to be done. It is equally self-evident that procedures devised for one task would, when they became known, stimulate the application of the same or related procedures to other problems. New observations and new manipulations of observations lead to new insights into purely climatologic questions.

The climatic aspects of problems in many fields that have no concern with biologic phenomena are likewise handled vaguely and remain essentially undefined because of the inadequacy of our present knowledge of climate. For the heating and ventilating engineer, a knowledge of the microclimates of a city is essential. The variation of temperature, moisture and wind with height as well as horizontally is enormously complicated by the structure of the city itself and the many disturbances which it creates. The climate at the tenth story level near the heart of a city will differ in many respects from the climate in a residential community in the suburbs, and the standard climatologic observations will probably not be representative of either situation. In the parts of the country where fuel is rationed, the application of a uniform formula that takes no account of microclimatic variation, will bring much more discomfort to some people than to others. Similar illustrations could be drawn from hydrology, highway engineering, medicine, military science and many others.

In the practical application of meteorology to weather forecasting, climatology can be of much service. The normal diurnal and annual march of means of the climatic elements are of great value in the interpretation of the synoptic weather map. Most important in the formulation of detailed local forecasts are statistical analyses of the climatic data to determine the probability that individual weather elements will depart from the normal by specified amounts.

An Institute for Climatic Research

There is at present no agency in the United States that is in a position to offer the assistance asked for by scientists who, in the prosecution of their investigations, encounter climatic problems. In the Federal Government, neither the agencies where the problems involving microclimatology arise, such as the Bureau of Plant Industry, the Forest Service, the Soil Conservation Service, nor the Weather Bureau where the task of obtaining standardized climatological observations has been so conscientiously performed, possess the facilities for assuming leadership in this new field. Nor do the present resources of the State agricultural experiment stations permit them to take the lead in applied climatology.

The courses in climatology that are found in many universities and colleges have usually been established and are usually maintained by departments of geography. Geographers have been interested in the science of climatology almost exclusively as a key to the regional differentiation of the earth and consequently have concentrated on descriptive climatology and on the classification of climate. To them the prime purpose of climatology has been to reduce the baffling complexity of climate to a system that would explain the differentiation of the earth's surface with respect especially to biological phenomena.

Much of the current literature of climatology is written by the geographers. The data of observation published in convenient form by the meteorological offices of the various countries invite further working up and generalization. This easily accessible material will provide the means for refinement of climatic maps and for comparable work during an indefinitely long future. The study of descriptive climatology has, thus, been diligently pursued and bulletins and monographs on the climate of particular regions and places are numerous. Honest and useful as much of this work is, it seldom gets down to sufficient detail to be of use in individual practical problems.

The fact that climatology has in the past been largely descriptive and is not now developed to a point where it can contribute to the solution of the many urgent practical problems in agriculture and biology is in part a consequence of the departmentalization of knowledge in colleges and universities. Facility in the development of instruments for measuring the climatic elements demands knowledge of physics and mathematics; and facility in the analysis and interpretation of climatic data, once they are obtained, requires a knowledge of statistics and meteorology. But biologists do not ordinarily study physics, mathematics, and statistics. Geographers, who have a very real interest in climatology, usually study neither physics and mathematics on the one hand nor biology on the other. Physicists are absorbed with their own special problems and are not aware of the acute need that others have for the assistance that they could give. In our universities today, courses of study are so inflexible and prerequisites so extensive that it is difficult in a four-year period for a student to get the training that would lead to competence in physical climatology.

It appears, therefore, that there is a place in the United States for a new agency, an institute for climatologic research. Such an institute can scarcely come into existence fully formed and fully armed, but must attain its final character gradually through the work it accomplishes. It would be sufficient as a beginning to have assurance of the continuous support for several years of a staff of two or three professional workers and their clerical assistants. Even ultimately the permanent staff would not need to number more than five or six.

The institute should be affiliated with a first-rate university which includes an agricultural college and experiment station. This would provide its first and most important connection. It would also have connections with agencies of the Federal Government, particularly the several bureaus of the Department of Agriculture. Most of the research undertaken would be collaborative; and while that work was in progress representatives of agencies situated elsewhere might be temporarily in residence at the institute. Members of the institute's staff should also be moderately foot-loose, so that they might visit other institutions when occasion arose.

In addition to their collaborative work in applied climatology, members of the permanent staff would have their own research problems, which would usually be problems in physical climatology. Reworking and interpreting the data published by the Weather Bureau will always provide work for many persons and the staff of the institute would participate in that work of interpretation. Of more importance are tasks that are not likely to be touched by the Weather Bureau. One such task is the development of instruments and methods of observation of temperature, light, humidity and wind, as actually experienced by plants growing under natural conditions. The installation of instruments in dense nets over restricted areas in order to investigate local problems is another. A third is the application of

statistical procedures to climatic data by means of which new meaning may be extracted, and the devising of new statistical procedures adapted to this end.

Many of the jobs undertaken in collaboration with nonmembers of the institute would raise physical and statistical questions that could be answered only by special investigation. When a permanent organization is attained, the staff of the institute would include a member having special competence in statistics, another particularly skillful in the devising of instruments, and so forth. Each member of the staff would usually have at least two research problems going on at the same time: one in his own field of physical or statistical climatology, the other in applied climatology carried on in collaboration with a specialist in another field.

An exceedingly important task of the institute would be the training of climatologists. This consideration is a further powerful reason why the institute should be articulated with a good university. The training offered would be on the graduate level, as is the professional training in meteorology given at several institutions in the United States. An attempt would be made, however, to avoid overspecialization. Since the institute would emphasize collaborative research, students would be expected to acquire a rather broad acquaintance with other sciences. They would be asked to acquire, if possible, a more than superficial knowledge of some field besides climatology, so as to be equipped to work with specialists in that field. This subject might be one of the specialized biological sciences such as entomology or plant pathology, a branch of engineering, economics, or medicine. The student's specialized preparation for graduate work in climatology would be heavily weighted with mathematics (including statistics), physics, and meteorology. Since graduate students with a wide range of backgrounds would apply for admission, the schedule of prerequisites would need to be flexible. The institute would rely on existing personnel in the regular departments of the university to provide undergraduate training. The institute's staff would, therefore, include professors from these various departments in addition to its full-time members.

The principal outlet for trained climatologists, at least in the beginning, would be in such Federal agencies as the Weather Bureau, the Soil Conservation Service, the Forest Service and the Bureau of Plant Industry, whose work touches climate at many points. A large proportion of the students might be young employees of these organizations on leave or on detail, who would return to their respective bureaus at the end of their training. If the institute proved to be as useful in the scientific world as our experience leads us to expect it to be, men with the training it afforded would soon be in demand elsewhere than in these Federal agencies. Once the potentialities of applied climatology were demonstrated, every agricultural college and experiment station would have use for at least one climatologist. His job would be to work with the agricultural specialists in the solution of their climatologic problems and to give students a practical knowledge of climate.

We have in the United States an example, in meteorology, of the fruitfulness of initial assistance in the establishment of instruction and research in a subject poorly represented in the universities. From a small beginning made possible by modest support from an educational fund has come a renaissance of synoptic meteorology that has brought back to the United States the leadership in the field it established and held fifty and sixty years ago. In its own way climatology promises an equally rich return.

THE PROGRESS OF SCIENCE

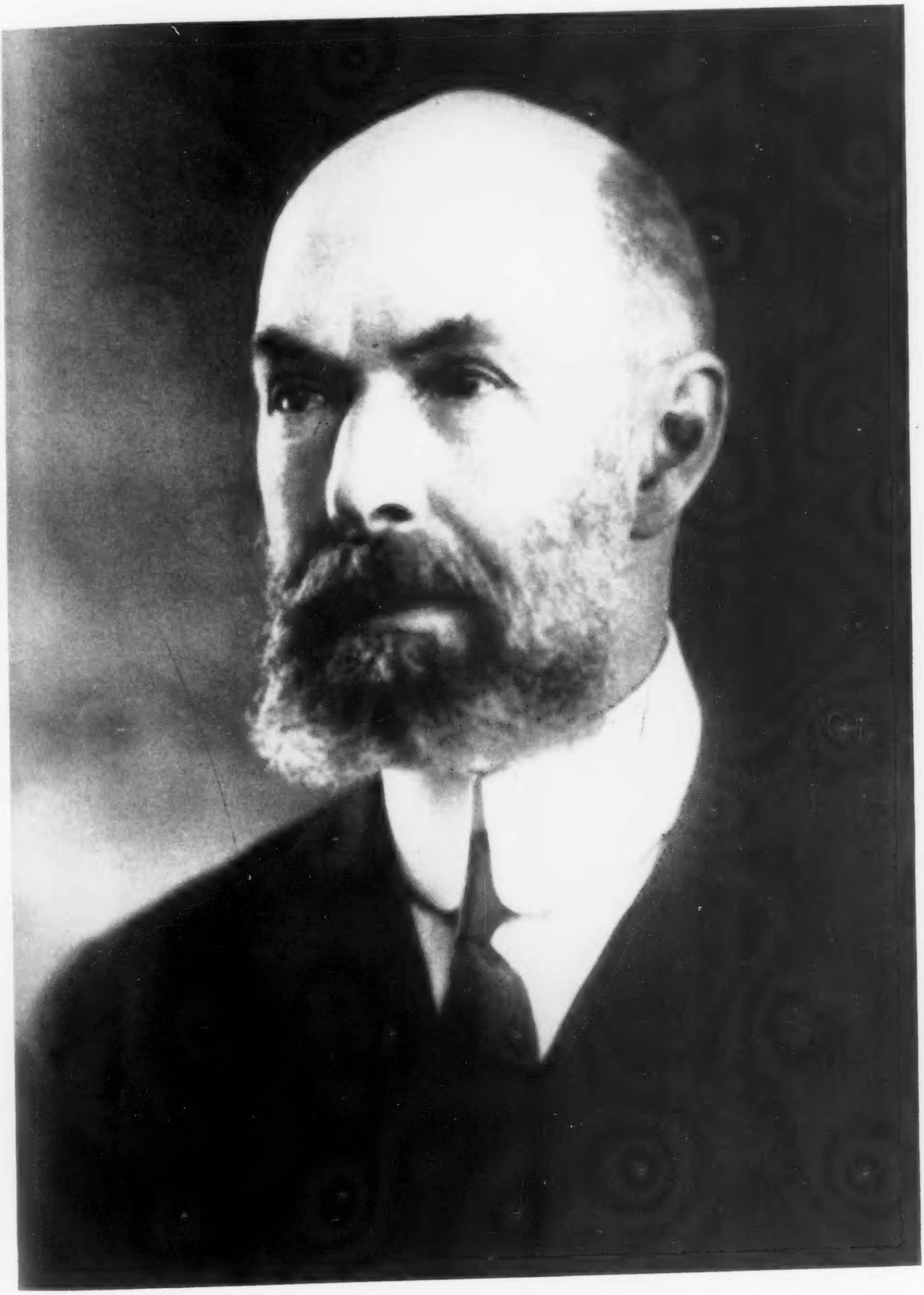
WILLIAM FOGG OSGOOD AND AMERICAN MATHEMATICS

William Fogg Osgood, Perkins Professor of Mathematics, emeritus, in Harvard University, died on July 22, 1943, at his home in Belmont, Massachusetts. He was one of the outstanding figures in the group of Americans responsible for the notable development of American mathematics which began about 1890. Inspired by European study, mainly in Germany, these men set out to do their utmost to foster mathematical scholarship and research at home. Among these, E. H. Moore of Chicago, Osgood and Bôcher of Harvard, E. B. Van Vleck of Wisconsin, White of Vassar, and Pierpont of Yale were destined to become leaders by virtue of their mathematical accomplishments; others too, like Cole and Fiske of Columbia, and Fine of Princeton, also rendered service of the highest value to the cause of American mathematics.

Osgood was born on March 10, 1864, in Boston, a direct descendant of one John Osgood who came to Ipswich, Massachusetts, in 1638. As an undergraduate in Harvard College, Osgood received his first scientific stimulus from B. O. Peirce, a mathematical physicist of distinction. After his graduation in 1886 there followed one graduate year in Cambridge, Eng., and three fruitful years of mathematical study in Germany where Osgood came under the influence of a great mathematician and teacher, Felix Klein, and underwent what can best be characterized as a *conversion* to German-European ideals in the mathematical field. These were naturally congenial to his thorough-going and systematizing temperament. Thus there opened a veritable new world to the young Osgood. Indeed Klein, organizer in the nineties of the remarkable German Mathematical Encyclopedia, not only determined the direction of his later scientific development by asking him to write the article in the Encyclopedia on "functions of one or more complex variables" but, it may be suspected, furnished an exemplar which Osgood emulated as teacher, as investigator, and as man.

After his European sojourn, Osgood became a member of the mathematical staff at Harvard University and so continued throughout his entire active academic life. He might have gone elsewhere, had he been less devoted to New England, to Harvard and, above all, to its Department of Mathematics. Of the honors received by him here and abroad, perhaps there was only one that really meant much to him—his election as eighth President of the American Mathematical Society (1905–06). Osgood might have said in justification of such an attitude: "In our Society there has been a sustained scholarly tradition on a high level, to which I have given my utmost. I am honored to have my mathematical work so recognized by this body of friends and colleagues with ideals like my own." The same type of realistic analysis, ruthlessly applied, led him to discount heavily, and even to be averse to, honors which were generally appreciated by others.

His teacher, Klein, was not himself a logical thinker of arithmetic type, being inclined to an intuitive, more geometric mode of reasoning. Yet he saw that Osgood was just the right person to construct a satisfactory basis for the geometric methods which Riemann had used in the field of functions of a complex variable and which were notably lacking in Weierstrass's wholly non-geometric but rigorous approach based on power series. It was the splendid fulfillment of this important task which absorbed most of Osgood's scientific life.



WILLIAM FOGG OSGOOD, 1864–1943

His *Lehrbuch der Funktionentheorie* of 1907 was the principal outcome, containing his most significant work in the field. This volume, which has gone into five editions and to which two supplementary volumes were later added (1924, 1932), for decades served everywhere as an unrivalled treatise on the subject. It is still unsurpassed as a basic text, although an even more geometrical (*i.e.*, topological) point of view is expounded in recent modern books based on the work of the Finnish school. Without exaggeration it may be said that this work of Osgood is "one of America's greatest contributions to the develpment of mathematics."[1]

The reason why this book appeared in the German language instead of English lay in a certain characteristic hard-headedness of the author. Osgood then felt, probably correctly, that if the book were to be published in America, it would be less widely used; and so he decided to publish it under German auspices. The widespread favorable reception of the book by the mathematical public, and the fact that no pressure ever developed in this country to have the work translated into English seem to have justified Osgood's decision at the time he made it, although the conditions for American mathematical publication have since become excellent. It fell to Osgood himself, during two very interesting years after his retirement in 1933, when he served on the staff of the National University of Peking, to produce a simplified English version of the first volume of his treatise.

Osgood's unrelenting mathematical practicality lay at the basis of his mathematical successes and explained his limitations as well. In his first paper of consequence, published only in 1897 when he was thirty-three years of age, he took a significant step in the direction later to be followed by Lebesgue (1904) which led to the Lebesgue integral, of vital importance in modern analysis. The reason why Osgood went no further was that the classic Riemann integral sufficed for the kind of problem which he was considering at the moment. Likewise Osgood felt that the so-called Heine-Borel theorem was a "process of thought" rather than a true theorem; here he manifested an almost perverse prejudice against purely abstract forms of mathematical thought. On the other hand, the same practicality led him to ask whether a Jordan curve has necessarily a null planar area, and so to construct an illuminating example of such a curve with positive area. Similarly, he saw that an ordinary minimum of a function has the obvious property that, for values of the independent variable differing by at least a certain amount from the value affording a minimum, the function will exceed this minimum by at least a specified quantity; this led him to "Osgood's theorem" in the calculus of variations which states that a like property holds for the minimum of integrals taken along a curve joining two fixed points. Again, by means of a simple example, he showed that, even under very favorable circumstances, variables cannot be eliminated in the case of transcendental equations in the same way as in the case of algebraic equations; and thus he threw important light on some of the difficulties to be faced in the study of such transcendental equations.

From the days of his undergraduate work with B. O. Peirce, Osgood always retained an interest in classical dynamics and physics. His vectorial treatment of gyroscopic motion (1922) simplified the subject by affording an elegant geometric approach to it.

His textbooks on the calculus, elementary and advanced, were perhaps the first to be written in the English language

[1] R. C. Archibald, *A Semi-Centennial History of the American Mathematical Society, 1888–1938.* 1938, I, 155.

from a careful scholarly point of view, and have exerted a widespread influence. He also wrote a book on plane and solid analytic geometry (with W. C. Graustein), and one on mechanics, both of which have been definitely useful. His primary motive here was to furnish a sound introduction to the student beginning the study of mathematics and its applications. Osgood was always a capable and conscientious teacher at all levels of instruction, and, at least in the early part of his teaching career, painstakingly graded exercises in his courses.

Not many students were inspired by Osgood in their research work, and the reason is not hard to find. His method of attacking a problem was to make an exceedingly careful and systematic exploration of details; it was thus that his own creative ideas came to him after arduous effort. It was natural then for Osgood to suggest to the prospective student desirous of working with him that he first make a careful preliminary routine survey of the field. But the average student was discouraged at the very outset by the unaccustomed labor, which was thus required, without apparent reward.

The indebtedness of the Harvard mathematical tradition to Osgood and to his colleague and intimate friend, Maxime Bôcher (1867–1918), is very large indeed. These two men, more than any others, established our standards of scientific accomplishment, and saw to it that the younger men in the Department had the same privileges as the others, and an equal voice in the conduct of its affairs.[2]

On the personal side Osgood was decidedly urbane, and made an extremely pleasant companion. It always seemed to me that, without much change of personality, he could have become a successful practical man of affairs. Of course such a career would have held no interest for him.

The American mathematical community generally, many former students, and his friends and colleagues will always remember with deep gratitude his single-minded devotion to the highest ideals of scholarship, and in so doing will be the more resolved to maintain for themselves a like elevated goal of idealistic achievement.

GEORGE D. BIRKHOFF

[2] See J. L. Coolidge, "Three Hundred Years of Mathematics at Harvard," *American Mathematical Monthly*, Aug., 1943.

EPIDEMIC KERATOCONJUNCTIVITIS

IT is now more than two years since a non-bacterial keratoconjunctivitis appeared in epidemic form in continental United States. Since that time the disease has temporarily incapacitated many workers engaged in important war industries, and in a significant percentage of cases has inflicted semi-permanent or permanent corneal damage sufficient to remove the individuals from the ranks of skilled workers.

The first area to feel the effect of the keratoconjunctivitis was the West Coast.[1] Because the disease, if unchecked, appeared to have a high non-effective rate, and because it appeared capable of spreading over a large area, its progress was observed with some trepidation. An intensive investigative program (initiated by the Division of Preventive Medicine, Office of the Surgeon General; and the Commission on Neurotropic Virus Diseases, Board for the Investigation and Control of Influ-

[1] M. J. Hogan and J. W. Crawford, *Am. J. Ophth.*, Sept., 1942.

enza and Other Epidemic Diseases in the Army) appeared justified when epidemic keratoconjunctivitis spread from the West Coast to New York City, where it soon affected hundreds of individuals. About this same time, cases were reported from the Albany-Schenectady area in numbers which approached epidemic proportions. On the West Coast the disease persisted in endemic form. In the East, it has left its mark along the entire length of the coast and has travelled as far south as Florida, and inland to Texas and Chicago.

There are certain differences between the Western and Eastern outbreaks which may be noted, since a comparison of statistics and clinical data suggests that the disease increased in virulence during its travel from west to east. In California, the patients were usually incapacitated for one or two weeks and the complication of corneal opacities appeared in forty to seventy per cent. of the cases. In the East, on the other hand, subjective symptoms were distressing in the majority of cases and the acute, incapacitating stage frequently lasted two, three or more weeks. Opacities were observed in as high as eighty-five per cent. of the cases. Furthermore, the objective clinical appearance seemed to be more severe with particular reference to edema and tearing. However, it should be emphasized that in spite of minor variations, the diagnostic features appear to be constant from epidemic to epidemic.

At the present writing there is reason to believe that the problem of epidemic keratoconjunctivitis has become less pressing. It is, of course, impossible to prophesy what the future may bring—whether the disease will follow a course of increased virulence or whether it will retreat into a relatively harmless state.

The clinical picture characteristic of epidemic keratoconjunctivitis is as follows. There is an acute conjunctivitis in which edema, especially of the upper lid, is predominant. The conjunctivitis may be follicular and hyperemia is marked. The follicular hypertrophy is probably due to a localized increase of lymphoid cells within the stroma of the conjunctiva,[2] and results in the appearance of small areas of glistening, raised mucous membrane. At this stage patients frequently complain of a foreign body sensation and while lacrimation is marked, secretions are minimal. It is not unusual for the symptoms to appear before there are marked anatomical changes. However, the follicles are often disguised by edema and lymphoid hyperplasia occurring in the diffuse cellular elements in the deeper connective tissue. The anatomical result in the event of deep lymphoid hyperplasia is a massive outpouching of the palpebral mucous membrane, dramatically apparent when the lower lid is pulled down. Bulbar involvement is usual and the chemosis may be so severe that bulbar mucous membrane projects between the lids. A fully developed severe case of epidemic keratoconjunctivitis presents a fearsome picture.

Associated with these signs and symptoms is a lymphadenopathy of varying degree, which involves the preauricular or cervical and submental glands. Tenderness may be extreme and chewing quite painful. It is not unusual for patients to complain of pain, apparently referred along the mandible. The lymphadenopathy may be present for only a few days or may persist for weeks after the acute signs have subsided.

Conjunctival scrapings made during the acute phase of the disease are not particularly significant. They may show occasional lymphocytes or large mononuclears. However, if a secondary invader is present a polymorphonuclear reaction may be evoked. Bacteriological studies of the secretions are essentially negative and are either sterile or contain non-pathogenic organisms.

[2] Personal communication, Alson E. Braley.

The intensity of clinical signs and the severity of the disease vary greatly from patient to patient within the same epidemic and, indeed, within the same household. The majority of cases are unilateral. In bilateral cases there is a tendency for the disease to be milder in the second eye. It may be noted that prognostications concerning the final outcome cannot be made on the basis of early clinical appearances.

The most frequent and serious complication is involvement of the cornea which occurs from one to several weeks after the onset of the acute conjunctivitis (usually seven to ten days after onset). It is not unusual to see cases with severe conjunctival envolvement go on to spontaneous recovery in about ten days without development of corneal opacities. On the other hand, a rather mild conjunctivitis may persist for weeks and be resolved by formation of many opacities with impairment of vision.

It has been noted by workers at Johns Hopkins that some degree of staining with fluorescein occurs during the development of the opacities,[3] but it is generally agreed that when fully developed, they are subepithelial in character and do not stain. Although the first sign that the cornea is involved may be pain or photophobia, in a surprising number of cases the infiltrates appear so subtly that the patient may notice only gradual blurring of vision.

The outcome of the opacities varies. On the West Coast blurred vision was generally transient. In the East, there was a tendency for the opacities to persist more often than they disappeared.

In general, disability occurs for one of two reasons. The patient may be unable to work because of ocular discomfort attendant upon an acute, severe conjunctivitis which lasts for one to three weeks. In the presence of opacities, vision may be sufficiently blurred to prevent the patient from carrying out his duties. The latter may last for much longer periods of time.

Since bacteriological studies in an obviously infectious disease were essentially negative, it is not surprising that a virus was suspected as the etiological agent. In March, 1942, at the College of Physicians and Surgeons, a virus was isolated from the eyes of two patients suffering with epidemic keratoconjunctivitis.[4] Later, four more strains were isolated under similar circumstances at the same institution.[5] This work is in the process of confirmation.

Epidemiological observations over the course of more than a year consistently point to contact infection as an important link in the chain of infection. Whether this is the sole means of spread is not clear and the possible role of the carrier and of trauma must also be considered. From the public health and industrial points of view, however, contact infection certainly is of prime importance. Thus, the need is paramount for hygienic procedures in homes where individuals are infected and wherever patients are seen or treated. Too many cases of disease transmission from patient to patient, from patient to physician, and from physician to patient have been authenticated to leave any doubt as to the importance of contact infection.

In view of the consistent and frequently persistent lymphadenopathy, it was not surprising to find neutralizing antibodies against the experimentally isolated virus in the blood of patients recovered from the disease. In a recent survey of more than three hundred serums certain data were obtained which may provide information on the problem of epidemic keratoconjunctivitis.[6]

[3] Personal communication, A. E. Maumenée.

[4] M. Sanders, *Arch. Ophth.*, Oct., 1943, Vol. 28; M. Sanders, R. C. Alexander, *Jour. E. Med.*, Jan., 1943, Vol. 77.

[5] M. Sanders, F. D. Gulliver, L. L. Forchheimer, R. C. Alexander, *J. A. M. A.*, Jan., 1943, Vol. 121.

[6] M. Sanders, R. C. Alexander—unpublished material.

The tests were carried out by number and no clinical data were provided until the results of each test were known. Normal serum specimens were deliberately submitted with acute phase (where possible) and convalescent phase serums. While no neutralizing antibodies in the blood of normal individuals were demonstrated against the experimentally isolated virus, positive findings in four familial contacts suggest the possibility of subclinical infection. However, far too few "contact" serums have been done to warrant a definite statement on this matter. Of the authenticated convalescent specimens more than ninety-five per cent. showed definite immune response which could be demonstrated by neutralization tests with the mouse virus.

Another result of the survey was the demonstration of the psychological response of physicians to the educational program initiated by the Surgeon General's Office. It became apparent that epidemic keratoconjunctivitis was a popular diagnosis and was being made in other types of conjunctivitis. It was not unusual after a negative test to check back clinically and find definite evidence that the case in point was not epidemic keratoconjunctivitis. It is thus manifestly important to properly place the disease by familiarity with the clinical syndrome. If this is done, spread of the disease may be prevented and we may find that epidemic keratoconjunctivitis is not one of the more contagious diseases. Another result of this survey suggests that the country-wide epidemics were due to the same strain of virus since convalescent serum from Massachusetts, New York, District of Columbia, Texas, Louisiana, Michigan and California neutralized the New York strain of virus.

Preliminary studies with the virus experimentally isolated indicate that the agent persists in and may be recovered from solutions commonly used in clinics where patients with foreign bodies in their eyes or with conjunctivitis are treated. These solutions include fluorescein, novacain, zinc sulphate, boric acid, mineral oil adrenalin hydrochloride and atropine sulphate.

From the foregoing considerations, it should be apparent that general preventive measures against the spread of epidemic keratoconjunctivitis include education of patients, contacts and physicians. This appears to be borne out by the results which have attended the efforts of enlightened public health authorities particularly in New York, Massachusetts, Maryland, Illinois and Michigan. Since the medical profession has become aware of the problem of epidemic keratoconjunctivitis no epidemic has been reported, although the disease is undoubtedly present in several areas where important industries are concentrated.

So far as treatment is concerned, the principal mainstay has been conservative measures of routine ophthalmological procedures for symptomatic relief. While there have been reports of success with the sulfonamides, this group of drugs given orally and applied locally has been of no avail—a finding which has been confirmed by entirely negative results obtained in the laboratory when the drugs were tested against the experimentally isolated virus. While some hopeful results were obtained with convalescent serum in a small group of patients,[7] a note of caution here, as in all therapeutic procedures, is indicated. As was noted earlier, there is a great variability in the course of individual cases and it is certainly not difficult to make fallacious observations concerning the efficacy of therapeutic agents, unless the observations cover many cases under controlled conditions.

MURRAY SANDERS

[7] A. Braley, M. Sanders, *J. A. M. A.*, March, 1943, vol. 121.

THE PORTABLE PIPE LINE

Modern "blitz" warfare based on the machine is crucially dependent upon petroleum transportation. At the outbreak of the war in 1939 the sheer weight of petroleum products in bulk represented an appalling problem and the exposure of oil-carrying trucks to air attack was another. As a result of research in these problems the portable pipe line was designed and put into effect. The designer was Sydney S. Smith of the Shell Oil Company Inc. which authorized an appropriation of $10,000 for experimentation in the Middle West.

The pipe line seemed to be the answer to the difficulties, such as hazards of bombing and poor surfacing, that were being presented by the Burma Road. A plan was drawn up which included some of the following features: twenty-foot sections of flexible pipe to follow the contours of the countryside, thus doing away with the necessity of digging trenches; pumping stations located at twenty-mile intervals; transportation of all equipment—pipes, couplings, pumps, etc.—by truck, trailer or mule; automatic stoppage of the flow at any point

PLACING A TWENTY-FOOT SECTION OF THE PORTABLE PIPE LINE

REGULATOR SECTION

along the line; automatic pressure controls to prevent trouble in case of a break.

The plan was accepted by the Chinese Defense Supplies Corporation interests and application was made to Lend-Lease for the required steel. Much of the pipe had been accumulated for transportation when the United States Army authorities decided that the portable pipe line was important for United States operations abroad. A survey had been made to determine the possibilities of installing a pipe line on the Burma Road, but when the Road was lost the 1,000 miles of pipe ordered for China was diverted to North Africa.

Tests were made by the Army in the Shenandoah Valley, Virginia. During the tests a flood washed out a bridge over which a portable line had been slung. The strength of the pipe was indicated by the fact that the bridge remained suspended on the pipe line alone and the connection was not broken. The only alteration in the original plan suggested by the Army was the reduction in size of the pumps to provide easier transportation. The result is that smaller pumps were located at ten- instead of twenty-mile intervals.

At least four portable pipe lines were used in North Africa during the recent campaign. They varied in length from 75 to more than 300 miles and they transported gasoline and water in separate lines. The rapid advance of the Allied Forces in Sicily was possible only because petroleum products, through the use of portable pipe lines, were able to follow the advance.

The line, having a capacity of 6,000 barrels (252,000 gallons) a day, is 4 and 6 inches in diameter. It can be laid at the rate of ten to thirty miles a day by unskilled or regular Army personnel and can be operated under the supervision of a few trained operators. The cost of material (not including transportation or labor) is about $3,000 a mile.

No communication system is necessary because of the automatic cut-off and because only one kind of product is shipped through each line so as to avoid dispatching complications under battle-front conditions.

The light weight flexible pipe is made in twenty-foot sections, and each section weighing only ninety pounds, can be readily lifted and carried by one man. The pipe is spiral welded and the ends are grooved for Victaulic couplings. The total weight a mile, including pumping stations, is approximately thirteen tons. As the line is laid, gasoline can follow along immediately through the pipe. Maximum rate of filling the line is about 2.5 miles an hour.

Gasoline-fueled engines operate the pumps; they were originally mounted on rubber-tired trailers for quick and easy movement but, in order to save gasoline and rubber, the Army ruled that they were to be placed on skids instead. Being flexible, the pipe line is not nearly as vulnerable to bombing as a rigid pipe line. Also, damage caused by bombing, sabotage or other mishaps can be rectified quickly. An individual pumping station, if put out of action, can be replaced in a few hours. During the interval the capacity of the lines is reduced only about thirty per cent. and returns to normal immediately upon the installation of the new unit.

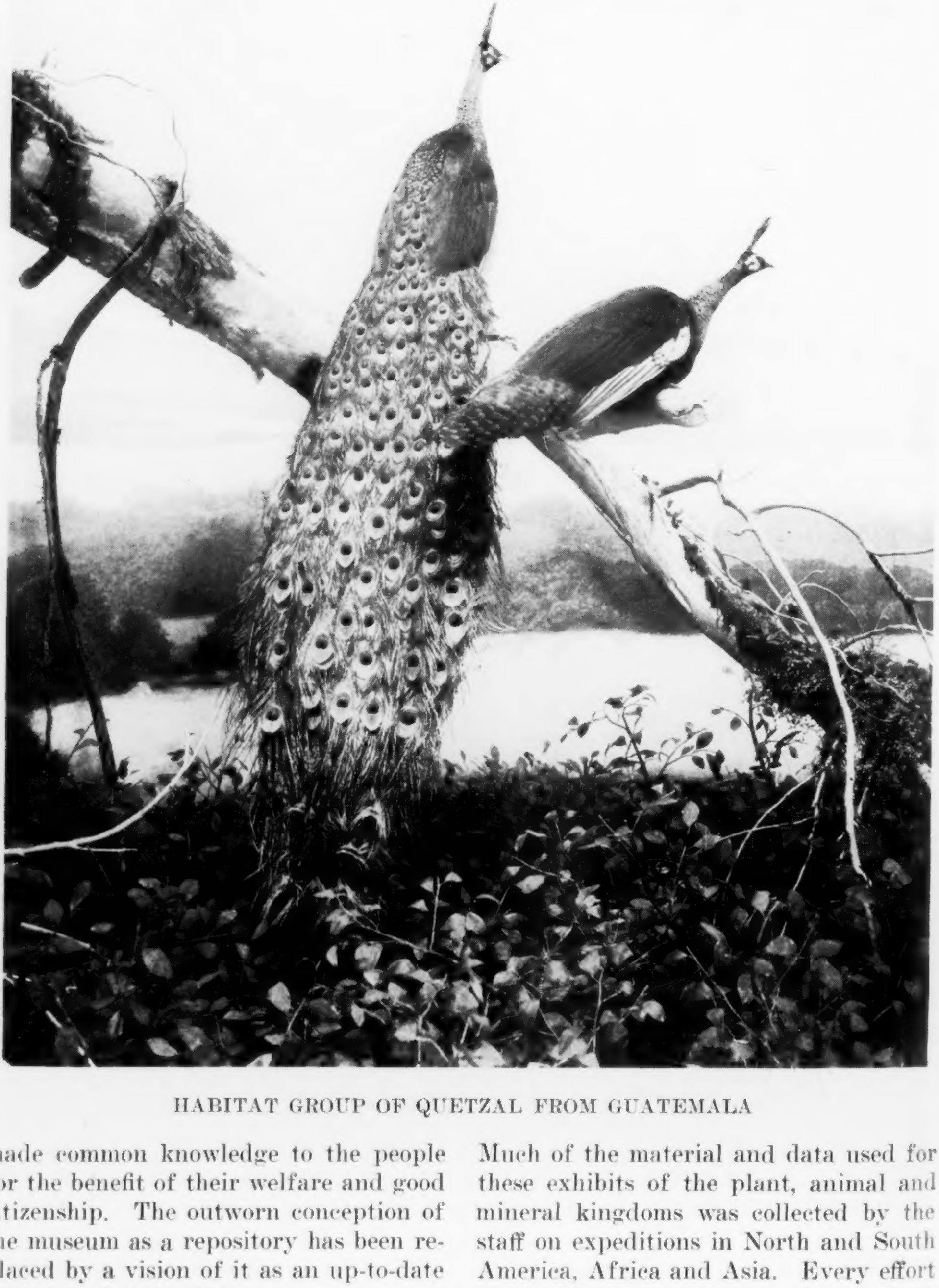
H. Wilson Lloyd

FIELD MUSEUM—FIFTY YEARS OF PROGRESS

On September 16 Field Museum of Natural History, in Chicago, celebrated the fiftieth anniversary of its founding by the late Marshall Field I. Within the short span of its existence Field Museum has, through the generosity of individuals, the foresight of its directors and the brilliant work of its staff scientists, become one of the world's four leading museums of natural history. The Museum was established as an institution to provide means for popular education along scientific lines and was dedicated to four great sciences—anthropology, botany, geology and zoology. For the fifty years since it grew out of the inspiration engendered by the success of Chicago's Columbian Exposition it has continued to broaden its scope and methods to include many important expeditions to all parts of the world, technical research, and education with special emphasis on attractive and instructive methods of museum display.

In half a century the Museum has sent out 440 expeditions, published 566 major scientific works, plus numerous handbooks, guides and popular leaflets. Its reference library has grown to include approximately 130,000 books and pamphlets, and its study collections, built on the research findings of its scientists, have become an important source for scientists all over the world. In the field of education, the Museum has made tremendous technological advances; it has worked with radio and pioneered in television programs and looked into the future when the museum will be brought into the home and the results of science

FIELD MUSEUM OF NATURAL HISTORY, CHICAGO



HABITAT GROUP OF QUETZAL FROM GUATEMALA

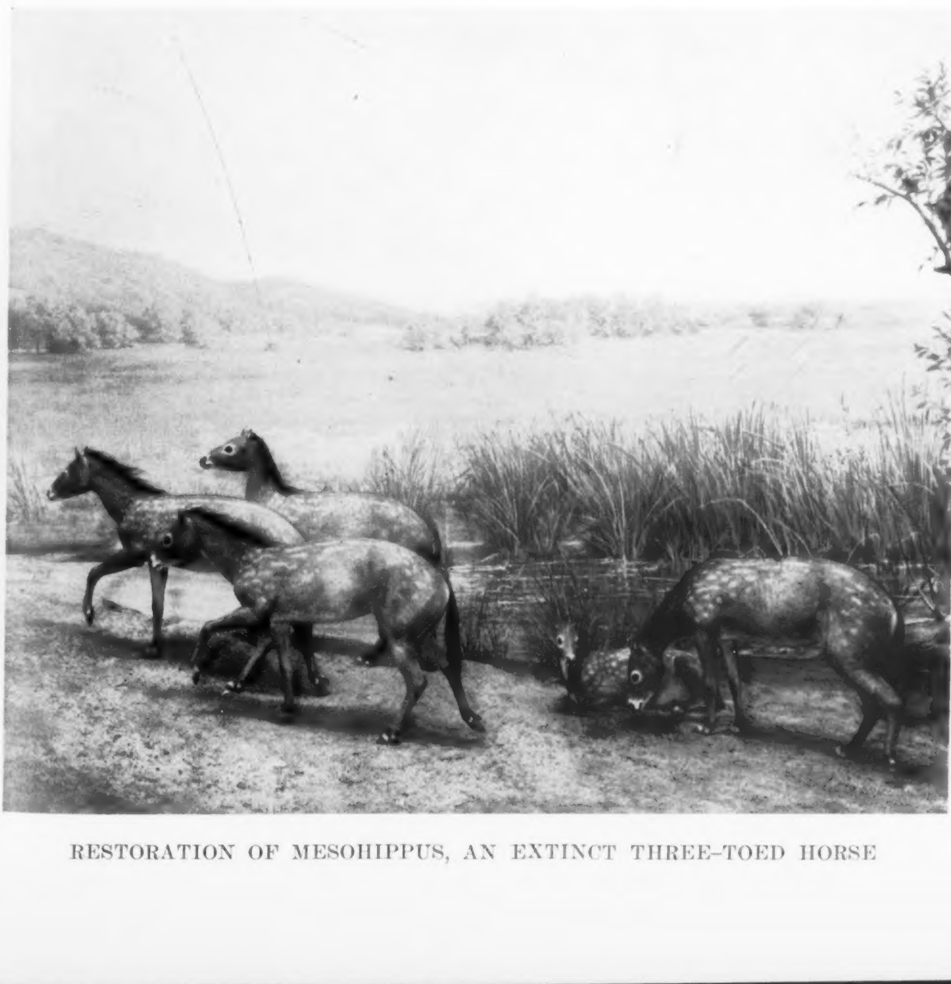
made common knowledge to the people for the benefit of their welfare and good citizenship. The outworn conception of the museum as a repository has been replaced by a vision of it as an up-to-date educator of the public.

Field Museum was one of the first to install habitat groups in natural settings. Much of the material and data used for these exhibits of the plant, animal and mineral kingdoms was collected by the staff on expeditions in North and South America, Africa and Asia. Every effort was made to create displays that are both striking and self-explanatory through the introduction of effective artificial

lighting, labels, drawings, maps and photographs. As a result, the thirty-three million who have visited the halls of the Museum have had the privilege of learning through enjoyment. Modern museum techniques are particularly well demonstrated in the new Hall of the Archeology of North, Central and South America, the completion of which has been interrupted by the war.

Members of the Museum's staff are making valuable contributions to the war effort. Their knowledge gained through expeditions and research is being used with important effect, especially with relation to geography of remote spots, such as the Solomon Islands or the Galapagos, that, for wartime, have become vital to our national security. Botanists are giving information about poisonous and edible plants of the tropics, geologists about the Arctic, zoologists about snakebite in South America and Africa, and entomologists about insect-borne disease. The vast sphere of the museum, far more important than is generally known, is suggested in the following words by Stanley Field who has been the Museum's president for the past thirty-five years: "Field Museum is a microcosm of the basic realities of this world. Embraced within the scope of the four great natural sciences to which it is devoted . . . are the fundamental elements of everything in life, and the causative factors that make people and other living things what they are."

In "Fifty Years of Progress," a special, golden anniversary issue of *Field Museum News*, staff members of the Mu-



RESTORATION OF MESOHIPPUS, AN EXTINCT THREE-TOED HORSE

RESTORATION OF SASANID PORTAL FROM ANCIENT CITY OF KISH

seum summarize the Museum's history and forecast its future. Stanley Field writes:

From the evidence before us today, it seems safe to predict that there will be two main trends in the future development of this and other great museums. First, with new conceptions of what constitutes true liberal education and what is necessary to adjust individuals to occupy their proper places as citizens of an international community which must be reorganized on lines of peace, humanity, and justice in all nations, museums may be expected to play an ever larger and more active educational role. Second, with the technological advances which were already apparent before the war, we may expect peacetime applications in the field of museology, as in all other fields, which will greatly increase the usefulness of museums. . . .

The way to the kind of world understanding which we all realize is needed—an international understanding that will make for peace and justice and fairness between individuals and between nations—is through an understanding of the forces of nature, a comprehension of the distribution of natural resources, a knowledge of plants and animals, and, most important, an unprejudiced and undistorted view of the character of other peoples, and of the effects of environment upon peoples.

M. D.

BOOKS ON SCIENCE

CANCER EDUCATION*

THIS is a very interestingly written book about our modern knowledge of cancer, but the reviewer did not have to read very far before receiving the distinct impression that the author was unable to critically evaluate the source material which he consulted in its preparation. The claims of numerous investigators long discredited or never confirmed have been given equal emphasis with well established facts. This is bound to result in confusing rather than clarifying the mind of the lay public concerning just what we really do know today about cancer. In the chapter on "Food and Cancer" so many conflicting so-called "authorities" have been quoted that the author in the last paragraph realizes that, "by this time the reader is doubtless thoroughly confused on the question of diet in relation to cancer." Then, leaning too far in the opposite direction, he says, "As a matter of fact it is felt by real cancer experts that diet has nothing to do with cancer." Only a very rash "cancer expert" would make this statement.

Although the publisher advises the reader to "Protect yourself by a careful reading of this authoritative book," it is believed that few if any cancer investigators would ascribe to the following quotations:

> "The diagnosis of cancer in its earliest possible stages is one of the great accomplishments of the modern cancer fighter."
>
> "One of the most interesting facts that has come to light is that cancer develops more slowly in well nourished and active individuals than in those who are anemic and in poor health."
>
> "Cancer of the stomach in its earliest stages can be detected by all surgeons."
>
> "It has been found that the essential differences between a normal and a cancer cell is a qualitative, not a quantitative one, which means that they are different in kind, rather than in quantity."

The activities of the American Society for the Control of Cancer and the various state cancer control programs in the field of cancer health education are not included in *The War on Cancer.*

R. R. SPENCER

* *The War on Cancer.* Dr. Edward Podolsky. 179 pp. 1943. $1.75. Reinhold Publishing Corporation.

HAND PSYCHOLOGY[1]

STUDENTS of human biology have gradually reached the realization that morphological, physiological and even psychological variations tend to occur in more or less definite combinations which form a variety of constitutional types. This fairly well established conclusion had, in a sense, been vaguely anticipated by several ancient and pseudo-scientific practices, such as phrenology and palmistry, which claimed to have discovered the mysterious correlations between certain detailed morphological features and intimate traits of personality, besides the past and future of an individual's fate.

The psychologist-author of the present book is a modern and sincere apostle of a new version of palmistry, or as it is now called, "hand psychology." In essence she attempts to demonstrate an unexpectedly close correlation between the detailed configuration of the hand and the outstanding traits forming the personality complex of the owner of the hands. Where one expects to find a summary of this book there is a final case-history from which the author concludes that the precise variations in the crease-lines of the palm are not only of diagnostic, but even of prognostic value for the correct interpretation of a person's emotional and mental peculiarities. To quote some of the author's novel claims: "From the *form* of the hand we may expect to derive a general impression of: (1) physical constitution and heredity; (2) emotional and instinctual potential

[1] *The Human Hand.* Charlotte Wolff. xvii + 198 pp. $3.00. May, 1943. Alfred A. Knopf.

—in short, temperament; (3) mentality and innate gifts and talents. From the *nails* and the hand's *physical qualities* we can find indications of heredity and health conditions. From the *parts* of the hand we should be able to decide: (1) the relative strength of *ego* and *id;* (2) the force of the will; (3) a more detailed conception than the study of the form of the hand alone elicits of the 'active' and 'receptive' aspects of personality." The *lines* in the palm, finally, are claimed to reveal "the strength or weakness of the super-ego" and give an idea of "the mental and emotional discipline," and various other conditions difficult to detect.

In spite of the author's scientific terminology, measurements, anatomical and medical discussions, and many plates of palm prints, her treatise remains unconvincing, to say the least. It is, however, a welcome reminder that we might expect eventually to find and prove a closer tie between morphological and psychological personality traits than is commonly believed to exist.

That Dr. Wolff shows more courage than care in arriving at her conclusions, is evident from the following startling and incredible claim: "I discovered that in respect of the length of the terminal phalanges only the brown capuchin monkey bears any close resemblance to man. This and other features which I observed seem to confirm the evolution of man not from the anthropoids but from a primary stock of New World monkeys which was the common ancestor of both."

In the preface by Dr. W. Stevenson it is stated that Dr. Wolff has made "a broad sweep over a new field of psychology" and that "this new branch of study . . . is ready for the polish of scientific elaboration later on." That polish is unquestionably needed and will have to be quite penetrating.

ADOLPH H. SCHULTZ

THE STORY OF SULFUR*

AT less than one cent a pound sulfur is by far the cheapest chemical element. At 99.5 per cent. purity it is the cleanest of raw chemicals. With over three million tons on hand it is one of our greatest war assets. The United States consumes more than thirty pounds each year for every man, woman and child, a total of two million tons. This is twice our usage of copper, three times that of rubber, five times that of tobacco. A knowledge of what sulfur means should be as commonplace in America as the knowledge of automobiles or of Yellowstone Park.

That knowledge has been available in every elementary textbook in chemistry. Now Mr. Williams Haynes, long-time editor of *Chemical Industries* and chemistry's ablest interpreter to the public, has made the entire story available in a book that is more fascinating than a novel, far more comprehensive than any textbook. The most fascinating part of the story is, of course, that of Herman Frasch and the development of his hot water process for bringing sulfur to the surface. Mr. Haynes has studied the record of the early nineties and unfolds the adventures and achievements of Herman Frasch as an American epic.

But "The Stone That Burns" is also a record of subsequent developments and of the present status of the industry. The appendix contains twenty statistical tables including such items as world sulfur production, sulfur content of foods, United States and world production of pyrites, and United States production of sulfuric acid. The book does not contain any discussion of the chemical industries based on sulfur, such as the manufacture of sulfuric acid.

GERALD WENDT

* *The Stone That Burns. The Story of the American Sulphur Industry.* Williams Haynes. Ill. xii + 345 pp. $3.75. August, 1942. D. Van Nostrand Company, Inc.

EXERCISES FOR SUPERMAN*

Now is the time for all good athletic directors to come to the aid of their cause. The urgent need for husky youths to man the guns and tote the loads of war justifies the present reopened clamor and ballyho for bigger and better muscles. Brawn and endurance are vital despite mechanization. Competitive college athletics are blacked out for the time being; if not wholly blacked out, at least as effectively as most communities are in their practice drills. There is a bigger, finer and more precious Alma Mater now: our Nation and our way of life. It is really win or die—no longer a mere game.

Thus a new book describing calisthenic exercises by a professor of physical education could be called both timely and apparently constructive. John Kiernan's typically brilliant and blessedly brief foreword is convincing even to the skeptic: there can be no question but that the author of the text is a great swimming coach and knows how to develop speed in Yale swimmers. But Mr. Kiernan's suggestion that the shocking number of rejections of young men called up under the Selective Service Act could have been materially reduced by even the most fanatic and devout attention to daily exercises is decidedly misleading. Statistics from the Selective Service itself reveal that the major reasons for rejections have been: Dental defects; visual defects; circulatory defects, including all forms of organic heart disease and disturbances of the blood pressure; nervous and mental disorders and musculo-skeletal defects or diseases, including amputations, congenital skeletal abnormalities and joint diseases. The frequency of none of these reasons for rejection, with the possible exception of a very few of the musculo-skeletal defects, is amenable to diminution through the medium of calisthenics, no matter how well planned, clearly directed and conscientiously carried out. The reviewer's own experience in the sad, perspiring grind of examining selectees for physical fitness has led him to feel that more lads are rejected because of overstrenuous athletic activity in adolescence than because of any lack of big bulging muscles.

It is furthermore significant that the Army physical training program has revealed that farm boys and white collar clerks develop endurance for the long grueling grind of military maneuvers quicker and to a higher degree than most high school and collegiate athletes. This is a sad blow to athletic coaches who have never appreciated the long-term meaning of the difference between speed in "sprints" and ability to endure less violent exertion for a longer time. American impatience and the cheers of childish alumni have given "sprint sports," whether on the field, on the track or in the pool, a wholly unwarranted prominence. Far better background for endurance is the steady plodding behind the plow or the dusty, scratching, sweaty job of stacking hay in the loft. Less "glorious," but far more constructive.

That calisthenics are of value in building muscles, developing better posture and assisting in the maintenance of health is not denied. It is their relative worth, in contrast to other factors in constructing health, which is open to question. The chief objection to the present book is the misleading nature of it's title: "How to be Fit." There is far more to fitness than bone and muscle. Included are such factors as mental ability; capacity to learn, to correlate and to judge; emotional stability; liberal functional reserve capacities of all the vital organs of the body and an implied promise of continued high per-

* *How to be Fit.* Robert Kiphuth. Foreword by John Kiernan. 131 pp. $2.00. 1942. Yale University Press.

formance in many activities. In other words, there are many kinds of fitness and many kinds of jobs to be done to win this war and to maintain a lasting peace.

The text of the volume consists of detailed, precise instructions for fifteen basic lessons, each with eight exercises and then an additional group of more strenuous exercises designed for young men working in groups or classes. Each exercise is clearly illustrated by superb photographs. The instructions are ample. All that remains necessary then, is the desire to posture, squirm, flex and stretch. One wonders how many readers will have the fortitude to continue through all these lessons without the lash of ambition for glory in sport or the harsh bark of the sergeant at drill. All the branches of the Armed Services have their own manuals of calisthenic drill and their own enthusiastic physical directors. We must not forget that equally effective as muscle and posture builders are exertions which entail pleasure and emotional relaxation or, better yet, accomplish some useful work in the doing. The book, though very well done, hardly seems necessary.

EDWARD J. STIEGLITZ

THE PSYCHIATRIC WORLD*

THE present volume is the second edition, thoroughly revised, of a book which first appeared only two years ago. That fact by itself is indicative of the progress in psychiatric therapy and of the author's clarity of presentation.

Much has been written of what may be termed psychiatric theory, of the dynamics and mechanisms of mental disorder, and there are available many descriptions of the symptomatology of mental disease. So true is this that the general public is sometimes prone to think of psychiatry in descriptive terms and not as what it really is—a specialty of medicine, and as such interested primarily in treatment and prevention.

Relatively few books devoted to psychiatric treatment have appeared, and Doctor Kraines' contribution serves a real need. The first fourteen chapters deal largely with the psychoneuroses; this is proper, for that group constitutes a large majority of the psychiatric disorders, common though the psychoses (the major mental disorders) are. Then follow chapters on the psychoses and other psychopathic states, on neuropsychiatric states in wartime, and on shock therapies. The general orientation is "psychobiological," which results in a rather light touch for anything savoring of the Freudian.

The therapeutic approach is conservative, but the tone is justifiably optimistic, and the advice given is sound. Although this book is written primarily for the medical student and practitioner, the interested layman will gain a wider horizon of the psychiatric world from its perusal.

WINFRED OVERHOLSER

* *The Therapy of the Neuroses and Psychoses.* Samuel Henry Kraines, M.D. 2nd edition. 567 pp. 1943. $5.50. Lea & Febiger.